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THE Editor of THE RAILROAD AND ENGINEERING JOURNAL is now engaged in collecting material which he contemplates using hereafter in writing a history of the engineering of American railroads. Parties who have in their possession, or know of the existence of, any drawings or documents available for this purpose—such as drawings of old locomotives or cars, maps, profiles, etc., reports, or any other documents, written or printed—will confer a favor by informing us of the fact. Any books, documents, or drawings which may be intrusted to the Editor for this purpose will be treated with the utmost care while in his possession, and will be returned safely to the owners.

THE steamboat men on the Mississippi have always been opposed to the building of any bridge over the river below St. Louis, and when permission was finally secured for a crossing at Memphis they sought to make it as difficult as possible by demanding a clear opening of 1,000 ft. The Board of Engineer Officers to whom the question was referred was divided in opinion, and the Secretary of War has finally decided to approve the original plan, which was for a three-span bridge, the center span to be 730 ft. and the others each 600 ft. long. The bridge is to be 75 ft. above the river, so that no draw will be required.

The final plans have not yet been submitted, and the method of construction to be adopted for these very long spans is not known, if it has been decided on.

THE proposed bridge over the Hudson River at New York City was recently the subject of a hearing before the Board of Engineer Officers, to whom the plans have been referred by the Secretary of War. The project submitted was that prepared by Mr. Gustav Lindenthal, which was described in our columns some time ago, and which is for a bridge with a single span of 2,850 ft. and a height of 140 ft. above the water.

Not much interest was manifested in the hearing. Mr. Lindenthal submitted arguments in favor of his plan, but only one or two persons appeared in opposition, and their only objections were that 140 ft. was not sufficient height for the bridge. The Board will submit a report to the Secretary of War on the question.

THE Poughkeepsie Bridge is rapidly approaching completion, and will probably be ready for use in October, as far as the bridge structure itself is concerned. Its connections, however, are still in the air, as very little has been done yet toward the construction of the line running from the Western end, and nothing at all on the branch road, which is to connect its Eastern end with the New York & New England road. Until these are finished the completion of the bridge will be of very little practical use.

There are rumors current, which seem to have some foundation, that large if not controlling interests in the bridge company, and in the New York & New England Railroad, have been obtained by the Vanderbilt interest. To the New York Central & Hudson River Company, the bridge alone is, of course, of no use whatever, but that the chief owners of that road should have considered it best to control the new rail connection for New England business is not at all improbable. The New York & New England road has been in the market for some time, apparently, without any one desiring to purchase it. The New York Central has derived so large a portion of its support from New England business that its owners could afford to invest a considerable amount of money to prevent more active competition for that traffic.

That could be done, as suggested above, by controlling the New York & New England, as it is the only important line likely to cross the river at Poughkeepsie. This road has done some Western business, but so long as it was hampered by the ferry transfer at Fishkill, and by its very imperfect terminal facilities there, it could not be regarded as a formidable competitor. With the bridge connection completed, however, and trains running directly across the river, the conditions would be changed, and it might be so used as to inflict great injury upon the Central. It is true that the Western connection over the bridge will be with the Erie and not with the Central, but turning over a portion of this business to its rival would be of less importance to the last-named company as long as the rates and connections were under its control.

Should these reports be true, the business of the bridge is likely to be smaller than its projectors have estimated, and to consist chiefly of coal and similar freights, rather than of through Western traffic.

THE plan for constructing a bridge over the English Channel has just been completed. It has been worked out by the Creusot engineers and M. Hersent, ex-President of the Society of Civil Engineers. The progress of metallurgy makes the construction possible of an immense bridge 30 kilos. long, with a floor at a height of 50 meters above the sea at full tide, and supported by piers at a distance of 500 meters apart. The Forth Bridge, which is being constructed in Scotland, under which the largest vessels can pass, is an advance toward this more important structure. The Channel Bridge will support four railroad lines, be-

sides a road for carriages and a foot-path. Places of refuge, watch-houses, and alarm-bells will be placed on each pier, with a powerful light. The bridge will cost 800,000,000 francs, and it might be constructed in six years.

The English Parliament recently refused, by a large majority, to pass a bill permitting the building of a tunnel under the Channel, and it is hardly probable that it will favor this scheme. The reason for this opposition is the fear that it may be used by an invading army to enter the country; but that seems a very poor one when we consider how easy a thing it would be to destroy or block up the tunnel or bridge.

THE production of pig-iron for the first half of 1888 shows much less falling off from the corresponding period of last year than had been expected from the general statements made with regard to the condition of the iron trade. The reduction is small in amount, and was chiefly in the anthracite furnaces, a number of which have gone out of blast, some on account of labor troubles and others from the high cost of coal, which has made it impossible to work at a profit in view of the present prices of iron. The production of iron by the furnaces using bituminous coal or coke show an increase, and the total amount—1,900,000 tons—was only 162,000 tons less than the very large output of the second half of last year. In charcoal iron also there was a small increase, but in quantity this class of pig-iron is not important, its amount being only 8 or 9 per cent. of the total production.

The condition of the blast furnaces on July 1, indicates that the production of the second half of the year will be less than for the second half of 1887, but it does not at present seem probable that the falling off for the whole year will be very large.

A NEW plan for rapid transit in New York is suggested by D. C. Linsley, an engineer, who is making arrangements to organize a company. His plan is for a masonry viaduct running through the blocks, crossing the streets at a considerable elevation, and the route he proposes is on the west side of the city, starting from the Battery and running for the most part west of all the present elevated lines to Spuyten Duyvil, from which point it is proposed to continue it as a surface line as far north as Tarrytown. Carrying the road through the blocks will, of course, require the purchase of a large quantity of real estate, but it is proposed to utilize this by building warehouses and shops in the arches of the viaduct.

The general plan of a masonry viaduct running between the streets is not a new one, having been often suggested, although the details have never been worked out so fully as in Mr. Linsley's plan. It is not apparent yet, however, that there is any considerable amount of capital behind this plan, and it is not probable that work will be begun very soon.

THE figures given by the *Railway Age* for the first half of 1888 include 3,320 miles of new railroad on which track has been laid this year. This is only about 400 miles less than the amount reported for the first half of 1887, when the total for the year reached nearly 13,000 miles. It is not to be expected, however, that the figures for 1888 will equal those of last year. A great part of the new mileage so far built has been in completion of that begun last year, and the number of new roads begun has been very much less; moreover, there are very few long lines now in progress, the mileage being made up of a number of short roads built by many different companies. The great companies, such as the Chicago, Milwaukee & St. Paul, the Chicago & Northwestern, the Chicago, Burlington & Quincy, the Missouri Pacific, and the Atchison, Topeka & Santa Fé, are doing comparatively little this year. The Chicago, Rock Island & Pacific, which did not begin to extend until late, has still a number of lines in progress, while the St. Paul, Minneapolis & Manitoba and the Northern Pacific are still pushing the construction of branches in Dakota and Montana. The Union Pacific has also several new lines under way, and will probably begin several others before the close of the year. Upon the whole, however, the prospect for new lines is not as good as it was a year ago, and the desire to build has apparently been checked by the unfavorable experience with new branches which those companies, which were the most active before, have had this year.

A very large proportion of the new road built so far this year has been in the Southern States, where there is still abundance of room, and where there has been, for the last year or two, a much healthier condition of things than in the West, the new roads being mainly feeders pushed into new territory, and not parallel or competing lines. Next to the South the most active building has been in California, where nearly 400 miles are reported, chiefly branches of the Southern Pacific and of the Atchison systems. Southern California especially will soon be pretty well supplied with railroads.

The estimate of 10,000 miles for 1888, which was made early in the year, will have to be reduced somewhat, and the figures will probably fall considerably below that. Enough new road will be built, however, to insure a fair degree of activity in the trades which furnish materials, so that no great depression is to be looked for.

Taking the whole country together, under its present circumstances, the growth of the railroads should be somewhat slower than that of population. An addition of from 3 to 5 per cent. yearly to our railroad mileage would represent about the normal and healthy growth which would be best for the prosperity both of the country and the railroads themselves.

THE launching of the *Charleston* at San Francisco, on July 18, marks another important step in the reconstruction of the Navy. This vessel, which has been built by the Union Iron Works, is the second—the *Chicago* being the first—of the large cruisers ordered for the Navy to reach the water; her displacement is one-fourth greater than that of the *Boston* and the *Atlanta*, and is only very slightly less than that of the *Chicago*, being 3,730 tons. The *Charleston*, moreover, is the first of the new ships constructed especially for high cruising speed, and the first whose plans were adopted under the present administration of the Navy Department. She is also the first ship to be fitted with the latest and best type of machinery, and it is expected that her engines will work up to 7,500 H.P., or more than twice the power of the *Atlanta*, although they occupy very little more space, and weigh only about 10 per cent. more than the engines of that ship.

The plans for the *Charleston* were not original, the vessel being in most respects a copy of the *Nanawa-Kan*, the famous cruiser built at Elswick, England, for the Japanese Navy, which was, when she entered into service, the fast-

est war-ship in the world, although her speed has since been exceeded by one or two. The plans of the *Nanawa-Kan* were purchased by the Navy Department from her builders, and used for the *Charleston*, with some slight alterations suggested by experience. The general dimensions of the vessel are 300 ft. long, 46 ft. beam, and 18½ ft. mean draft. She will be heavily armed, carrying a side battery of 6-in. guns and also two 10-in. pivot guns, with the usual secondary battery. She is what is known as an unarmored cruiser, the vital part of the vessel being partially protected by a curved steel deck, and the machinery is also further guarded by the arrangement of coal bunkers. She will be fitted with all the latest improvements in the way of electric lights, torpedo protection, ventilating apparatus, and so on.

SETTING aside a few torpedo boats which can only keep up their speed for a very short distance, it is now claimed that the German Navy possess the fastest armed cruiser in the world. This vessel, which was recently completed at Kiel, has a displacement of 2,000 tons, with engines of 5,400 indicated H.P. The *Greif*, as she is named, on the voyage from Kiel to Wilhelmshafen attained the extraordinary speed of 23 knots an hour. She has, as may be supposed, been built exclusively for speed, carrying a light armament, and having her space almost entirely taken up with boilers, engines, and coal bunkers. She is of the class of ship known as torpedo-boat hunters, and is the first of her kind in the German Navy, although the English have several. The *Greif* is undoubtedly the fastest naval cruiser in the world, considerably exceeding in speed the English 20-knot cruisers, and one or two which were added to the French Navy a short time ago. How long her cruising can be kept up is not stated.

THE bill which we have already mentioned as pending before the Massachusetts Legislature, authorizing the organization of a naval reserve as part of the State militia, has become a law. It provides for a naval battalion to consist at present of not more than four companies, and to have a full complement of officers. Officers and men alike are required to have sea experience, or to be engaged in seafaring pursuits. The complete operation of the law is dependent upon the co-operation of the United States Government, which is to be asked to furnish a vessel and guns for the training of the men ; but it is expected that there will be no difficulty in securing this assistance.

THE Japanese have for several years past shown considerable activity in railroad building, and their lines so far constructed have been very successful. The latest road proposed in that country is on the Island of Kiu-Siu, the most southern of the four large islands composing the Empire. The route proposed is from a port on the Shimonoséki Strait on the north end of the island to Nagasaki in the southwest, traversing the whole island and having several branches, the total length to be constructed being about 275 miles. There are now no railroads on that island, the only open port being Nagasaki, and the interior is less visited by foreigners than any other part of the Empire. It is known, however, that the population is large, exceeding 5,000,000 persons, and that a large part of the country is very productive. Moreover, a portion of the road will pass over extensive coal fields, which are now worked at Miiki, where a considerable amount of coal of very good quality is mined.

If built as proposed, and there seems to be a strong probability that construction will soon be begun, the road will differ from all others in Japan, from the fact that it will be owned by a private company and not Government. Under the laws of that country, however, the management will be under strict Government regulation. A preliminary survey is now being made by a German engineer, but it is stated that several of those who are most interested in the construction of the line advocate the adoption of American methods, and there may be an opportunity to furnish American material.

THERE has been started in the Argentine Republic a project for a railroad line to connect that country with Bolivia and Peru, and eventually to form part of a grand International railroad running the whole length of the South American continent. The transcontinental line from Buenos Ayres is now completed, or nearly so, to Jujui, a distance of 993 miles. The last-named place is only about 100 miles from the Bolivian frontier, and from it to La Paz, the capital of Bolivia, a distance of 500 miles, a new line would have to be built. From La Paz to Santa Rosa there is a line in operation 220 miles long, and from Santa Rosa through Cuzco in Peru and Santa Rosa in Ecuador, to Hiradot in Colombia, a distance of 1,520 miles, some of it through very difficult country, a new line would have to be built. From Hiradot to Bogota in Venezuela, a railroad 140 miles long is under construction. The total length of this proposed line from Buenos Ayres to Bogota, it will be seen, will be about 3,425 miles, of which 1,350 miles are completed, leaving 2,075 miles to be built. After reaching the table-land of Bolivia the road would follow the heads or upper waters of the numerous tributaries of the Amazon on the western side of the Andes, and would not anywhere have to cross the mountains.

A second line which has been indicated follows the existing road from Buenos Ayres to Santa Rosa, 450 miles, reaches La Paz in Bolivia by way of Asuncion in Paraguay, and follows from La Paz the same route as the first.

The length would not differ from the other very much, but it is claimed that it is a better one both for construction and traffic. Two or three other alternative routes have been proposed and discussed, and there are advocates for a line running up the Andes from Quito northward, which, it is claimed, would serve to develop the richest mineral country in the world.

The advocates for the construction of this South American International Railroad point to the great extent of valuable country which would be developed, and also to the fact that all the countries on the line would be willing to extend material aid both by grants of land and by guaranteeing interests on sums invested in construction.

Whatever line may be adopted, connections could be made with the Cerro di Pasco and other rich mineral districts by branches, while nearly the whole of the country can be made to furnish products for export which would give traffic to the road, which would furnish the best outlet. Bolivia, for instance, is a country known to possess very great natural resources which have never been developed simply because, while it is comparatively near the Pacific coast, everything going to the country westward

has to be carried across the Andes, while to the east its only outlet has been through the Amazon and its tributaries, whose banks are for many miles occupied by hostile Indians, and in which there are serious obstructions to navigation. The Brazilian ownership and control of the lower Amazon has also been an obstacle to commerce in this direction, as the republics of the western coast have always been jealous and somewhat afraid of their powerful eastern neighbor.

Buenos Ayres is more than 10 times farther from La Paz than Valparaiso, yet the former is much the more accessible port of the two by land.

The project, as a whole, is a very extensive one, but it really does not present more difficulties than did the Pacific railroad question in this country 30 years ago. The obstacles to its execution are more of a political and financial nature than physical, for it does not appear that there is anything on the line which cannot be overcome by competent engineers. It is not improbable that in some form it may be realized before the close of the present century.

AT the recent convention of the Society of Civil Engineers, one of its members said that he thought that the committee of the Master Car-Builders' Association should be dismissed for advocating an increase in capacity of cars. No doubt the Car-Builders will do this when they learn the wishes of the civil engineers.

THE committee appointed by the Society of Civil Engineers on the Relation of Wheels to Rails, about two years ago, seem to have difficulty in reaching conclusions. At the convention in Milwaukee, according to the *American Engineer*, they reported that much work had been done on this, and statistics had been gathered and were now in shape for a report, but the conclusions were not yet quite ready.

PROBABLY the most important engineering work now under way in Great Britain is the Manchester Ship Canal, work upon which has just been begun after a long period of preliminary agitation and discussion. This canal will form a connection between the city of Manchester and deep water in the river Mersey, partly by the construction of an entirely new canal and partly by the widening and deepening of existing water courses. It is intended when completed, to give a depth of 26 ft. of water up to the basin and docks in Manchester, and the entrance lock is to be made so deep that it can be worked at all stages of the tide, so that the delay now occasioned in entering the docks at Liverpool will not affect vessels going into the canal. The completion of this water-way, and the opportunity which it will offer to large vessels to go directly to Manchester, will save a very large amount, it is expected, in the expense of handling traffic which is now sent to Liverpool by rail for shipment. In the case of heavier goods this saving will amount to a very appreciable percentage on their cost.

The canal will serve not only the city of Manchester itself, but a large part of the district of which it is the center, and which is probably the most densely populated and active manufacturing district in the world. The estimate of its projectors is that very moderate tolls will insure an excellent return upon its cost, while the benefits to business generally will be very great.

THE use of the locomotive for drawing canal boats has often been proposed, but has never, we believe, been carried into practice. Some experiments of this kind have recently been made in England, where the question of the improvement of canals and their more extensive use is now under discussion. Without having any detailed account of the results of these experiments the general statement is, that they have been very successful, and it is proposed to extend the use of the locomotive for that purpose.

A light engine would be sufficient to haul several boats where the canal is in such a condition that they can be run together, and the laying of a track to carry such a machine on the towpath of a canal should not be an expensive matter. A heavy locomotive would not be necessary, and, indeed, would be out of place, for such tows as a 40 or 50-ton engine could take would be entirely impracticable on any ordinary canal, and there could not be any grades to overcome. The plan seems to be meeting with much favor in England, and is worth considering here. It has already been sufficiently proved in coal mines and logging railroads and for other purposes, that a locomotive is much more economical than animal power, and the extension of this principle to a canal ought to be a matter easy of arrangement.

IN Westminster Abbey in London, recently, the memorial window which has been placed there in memory of Richard Trevethick was uncovered, thus commemorating, fifty-five years after his death, one of the greatest of early English engineers. While Trevethick originated and advocated many of the ideas upon which later progress in steam engineering depends, he was himself unsuccessful, and died in great poverty. He was the first man to design a practicable locomotive; he advocated the use of a high pressure of steam at a time when such an idea seemed to most engineers absolutely chimerical, and in many other directions he had what seems to us a most extraordinary foresight. He was in advance of his age, and it is well that he has been remembered by a later generation, which has adopted his ideas.

A WEST VIRGINIA inventor has devised a pilot for locomotives, which, he claims, is not only an excellent cow-catcher and snow-plow, but will also do away with the disastrous results of butting collisions. His pilot, he says, "will in case of a collision throw both trains from the track, spreading the track, and forcing the locomotives to rake each other from the road-bed, a checked gradual derailment far less destructive to life and property than by direct collision." In other words, when this arrangement is used, should two trains meet upon the same track, instead of telescoping with mutual destruction, they will glide gently and quietly to either side of the track with all the ease and grace of a young lady and a gentleman meeting on a narrow sidewalk.

There is no doubt that such an invention will be extremely useful, and that it will render the train-dispatcher's mistakes perfectly harmless. It is not entirely complete, however, and needs an additional device, which might be attached to the rear of the train, to enable the two trains to return to the track after their gentle collision, or, rather, harmless derailment, and thus avert any evil consequences from lingering too long in close proximity, which might be almost as dangerous for trains as for the parties on the

sidewalk. Probably our West Virginia friend will be equal to this, however, and it will be enough to simply call his attention to the incompleteness of his invention in its present condition.

ACCIDENTS FROM "WALKING OR BEING" ON RAILROAD TRACKS.

IN their last report the Railroad Commissioners of the State of New York give the number of persons who were killed in the State from "walking or being" on railroad tracks as 341, and 222 more were injured. As there are about ten times as many locomotives in the whole country as there are in the State of New York, we may make a rough-and-ready approximation of the whole number killed and injured by simply multiplying the above figures by ten, which would give us 3,410 killed and 2,220 injured, or a total of 5,632. As these figures represent an appalling amount of pain, sorrow, and of consequential destitution, some general inquiries were sent out some time ago, in connection with an investigation of a similar character, to learn, if possible, whether the class of accidents referred to could be lessened, and, if so, by what means.

To the question, "Can you suggest any way of lessening the number of accidents to employés from 'walking or being on the track?'" the following replies were received from experienced railroad officers. A number answered "No;" four said "by staying off the track;" others recommend the enforcement of trespass acts; three suggest the use of a steam bell-ringer on locomotives; two propose a foot walk alongside of tracks; one proposes overhead foot-bridges, and another "a proper enforcement of rules in regard to speed through yards: a stringent rule requiring a brakeman to be on the front car of every train that is being pushed, and he to be held accountable; more care in the selection of employés for yard service; the use of bulletins giving all employés, particularly track and maintenance of way men, full information as to movement of trains, and the display of signals from elevated points for all delayed or unscheduled trains."

The Railroad Commissioners of New York say: "The danger seems to be inevitable, and incident to the occupation."

The Commissioner of Railroads of Michigan says: "Laws might be enacted providing a penalty for going upon a railroad track, but in most parts of this State would be a very unpopular measure, and one which there is no probability of the Legislature enacting. In fact, where the penalty is death for neglecting to care for themselves, it is difficult to see how much more can be done unless the railroads are fenced in such a way as to make it impossible for people to get upon the track."

The Chief Engineer and Manager of the Canadian Government Railways, in a reply to the Committee, said: "Regarding your suggestion as to the efficiency of notices placed at frequent intervals, I may say that my own experience leads me to the conclusion that they are wholly ineffectual. I have not only tried notice boards, but at certain points, when the track was especially made use of as a highway, I have stationed constables to warn off trespassers, and even to turn them off if necessary. This caused very bad feelings, and was even regarded as an infringement of the liberty of the subject. If the public could only be brought to support any movement to prevent people from endangering their lives in this manner, it would not be difficult to find a remedy. But at present it is quite the reverse."

The Commissioners of Mississippi say: "The plan adopted by the Illinois Central Railroad of posting conspicuous warnings to persons to keep off track, stating that it is company property and intended only for its use, and trespassers are at their own risk, is the best I know for lessening the number of accidents to persons walking on track."

The Secretary of Internal Affairs of Pennsylvania says: "The great danger of such a habit or practice should, we think, be evident to every one."

These replies show the futility of the means which have been adopted. Of course, fencing railroads, the abolition of grade crossings, or placing gates and watchmen at all such crossings are preventative measures, but their universal adoption on all roads is impracticable, and will be so for many years to come. Then there is no direct responsibility for such accidents. If persons will expose themselves to such danger railroad companies are not blamed for the results, if they use proper precautions to prevent them. It would be fallacious to say that it is as dangerous to walk or be on a railroad track as it is to go into a bloody battle, but the number of killed and wounded annually in this country as a consequnce of exposure to this danger is as great or greater than the loss of life and the casualties of many important battles.

The question occurs, then, why, if the danger of walking or being on the railroad track is so great, do people expose themselves to it? The answer is obvious, they do not realize it. Probably very few experienced railroad officers appreciate the imminence of the danger of being on the track, although they have for years been engaged in railroad employment. A few months ago the writer saw two ladies walking on the track of a railroad near a large city where there are frequent trains, with an umbrella which —to speak in a Hibernian way—was hoisted low down, so that it was impossible to see and difficult to hear an approaching train, and they seemed quite oblivious of their danger. The papers tell almost daily of persons who, in getting out of danger from an approaching train on one track, step into the jaws of death on another, on which there is a train moving in the opposite direction. The fact is, the Secretary of Internal Affairs of the State of Pennsylvania to the contrary notwithstanding, the danger of the habit or practice of being on the track is not evident to every one.

If it were possible to make persons realize fully the danger they incur the moment they are on the track of a railroad and not inside of the cars, much would be done to diminish the class of accidents referred to. It is usually the feeling of security which constitutes their danger. If they were alarmed and alert they would be likely to see and escape the risks to which they are otherwise exposed.

The thing to do then, if possible, is to make the danger apparent in any way that will be effectual. A notice that

A RAILROAD TRACK IS AS DANGEROUS AS A BATTLE-FIELD

might attract attention, but it is not strictly true. If conspicuous notices, somewhat as follows, were posted on railroad tracks where they are most needed, they would be

sure to alarm some persons who expose themselves to danger because they fancy they are safe on a railroad track.

IT IS DANGEROUS TO WALK OR BE ON A RAILROAD TRACK! MORE THAN 5,000 PERSONS ARE KILLED OR SERIOUSLY INJURED EVERY YEAR IN THIS COUNTRY AS A CONSEQUENCE OF EXPOSING THEMSELVES TO SUCH DANGER.

There is no hope that a notice of this or any other kind will prevent the practice of walking on railroad tracks, but it would have the effect of making many persons more cautious who now are very careless, and thus save some lives.

Another analogous class of accident on railroads is that of employés being struck by water-cranes, poles, walls, switch-stands, etc. Of these the Railroad Commissioners of the State of New York say that "the Board deems that this class of accidents could be greatly diminished by having such structures removed further from the track; and it deems that the distance should not be less than 5 ft. from the rails, and that all structures should be removed from between the tracks unless there is a distance between such tracks of at least 11 ft. A car projects about 2 ft. 7 in. beyond the rail. This proposed distance of 5 ft. from the rail, therefore, would leave but 2 ft. and 5 in. between the outside of car and the structure—none too great a distance."

No argument is needed on this point, but human life is cheap, and moving switch-stands and other structures cost money.

NEW PUBLICATIONS.

THE COAL TRADE: BY FREDERICK E. SAWARD, EDITOR OF THE "COAL TRADE JOURNAL." New York; published by the Author.

This is the fifteenth yearly number of a valuable work, which is, as its title-page says: "A compendium of information relative to coal production, prices, and transportation, at home and abroad."

It is a general review of the coal trade of the country, both anthracite and bituminous, the figures being taken from official sources wherever possible, and in all cases from the best available authorities, and carefully arranged and tabulated. The long experience of the Author and his intimate acquaintance with the trade have enabled him to work to advantage, and to make a book which is not only the best, but really the only convenient book of reference for this important trade.

How great its importance is will be seen when it is stated that the total output of coal in the United States last year was about 120,000,000 tons, being over one-fourth of the total estimated coal production of the world—a proportion which is yearly increasing, as the development of this industry is proceeding more rapidly here than in any other country.

ABOUT BOOKS AND PERIODICALS.

A CAREFULLY prepared paper, by Professor Arthur T. Hadley, of Yale College, on the "Rise and Growth of the Railway as a Corporation," will appear shortly in SCRIBNER'S MAGAZINE. The writer is one of the few who has made a study of railroad corporations, and is one of the leading authorities on this subject in the country. This paper will be doubly interesting, for just at present there is a great deal of interest in corporations with relation to the public and the law.

The third article of the Railroad Series, entitled "American Locomotives and Cars," appears in SCRIBNER'S MAGAZINE for August. It is by M. N. Forney.

The AMERICAN METEOROLOGICAL JOURNAL offers a prize of $200 for the best original essay on Tornadoes, or description of a Tornado; one of $50 for the second best, and $50 divided among those worthy of special mention. A circular giving full details can be obtained by application to Professor Harrington, Astronomical Observatory, Ann Arbor.

NEW YORK RAILROAD MEN for July contains an article on the Westinghouse Air Brake which is worthy of a careful reading; also the last of the three articles on Railroad Books in the Library, by James Eagan.

BOOKS RECEIVED.

REPORT OF HENRY A. HANCOX, C.E., ON THE WATER SUPPLIES IN THE VICINITY OF MILFORD, N. H. Published by the Selectmen of the Town.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution. The present issue includes Discharges from Circular and Egg-form Sewers, by William Thomas Olive; Compressed Oil-gas and its Applications, by Arthur Ayres; Indian Woods Suitable for Engineering Purposes, by Kuahya Lall Pai Bahadur; Arched Ribs and Voussoir Arches, by Harold Medway Martin; Creosoting Timber in New Zealand, by William Sharp; Economy Trials of a Non-condensing Steam-Engine, Simple, Compound, and Triple (with discussion), by Peter William Williams.

Another installment of these valuable papers includes Paved Carriage Ways in Sydney, New South Wales, by Adrian Charles Mountain; Machinery for the New Steel Works at Terni, by Hugh Savage; Manganese Steel (two papers and discussion), by Robert Abbott Hadfield; Abstract of Papers in Foreign Transactions and Periodicals.

FROM THE RECORD OF TESTS OF STEEL MANUFACTURED BY CARNEGIE, PHIPPS & CO., LIMITED, PITTSBURGH, PA. This little pamphlet contains tabulated records of a large number of tests of Bessemer and open-hearth steel made at the works of the company named, and showing the uniform quality of the product.

CROSBY STEAM GAGE & VALVE COMPANY: CATALOGUE, 1888. Boston; issued by the Company.

WELDING, TEMPERING, BRAZING, FORGING, AND SHAPING OF METALS BY ELECTRICITY: DESCRIPTION OF PROCESSES. Boston, Mass.; issued by the Thomson Electric Welding Company.

DWIGHT'S TRAVELERS' HANDY BOOK. Springfield, Mass.; published by the Dwight Print. This little book contains a sort of compendium of information for travelers; it comprises four parts: What to Do in Case of Accident; Rights and Liabilities of Passengers on Railroads; Railroad Signal Code Adopted by Leading U. S. Railroads, and other miscellaneous Useful Information.

Hypercycloidal Gear.

To the Editor of the Railroad and Engineering Journal:

Among the readers of the article upon this subject, published in your April number, were some who took sufficient interest in the matter to turn to your advertising columns, and finding my address there, honestly wrote to me for more information in regard to the "Hypercycloid."

It is true that the article mentioned was rather a description of results attained than details of how to attain them. These latter, however, as the law requires, are fully explained in my patents, which are not concealed.

It is interesting to see the effect, the lighting up of the countenance of a good mechanic, when he begins to realize that, as the ellipse may be of any proportion from a straight line to a circle, so the family of the Cycloidæ cover the same range—*i.e.*, from a straight line to a circle by another road; and as, in all the various proportions of the ellipse, the conjugate diameters and tangents are all subject to the same law, so in the Cycloidæ the tangents and secants have each a single value throughout the family. To quote from the patent referred to, "the tangent =

$$\sqrt{\frac{\text{sine}^2 + \left(\overline{\text{natural secant} - \text{cosine} \times \text{sine} + \frac{\text{sum } x}{6.2832}}\right)^2}{\text{sine}}},$$

and

$$\text{secant} = \text{cosine} + \frac{\overline{\text{natural secant} - \text{cosine}} \times \text{sine} + \frac{\text{sum } x}{6.2832}}{\text{sine}}$$

Also the versed sines are all natural, but the conversed sines vary from a minus quantity to infinity."

The common cycloid, epicycloid, and hypocycloid are all members, either simple or under especial limitations, of the family of the Cycloidæ. The involute is no relation of theirs, but one of the Conchoidæ, a cousin, so to speak, of the Conchoid of Nicomedes. In passing it may be remarked that the Conchoidæ, like the Cycloidæ, are a family whose range is from the straight line to a circle, according as x or y may $= 0$.

It is perhaps a weakness of human nature that causes a man who has done a certain thing in a particular way to try to do another thing in the same way, and if the result is tolerably fair, to look for no better way; and by continuing in the same practice to come at last to think that there is no other way. Now if any man likes to draw all of his water from one well he is at liberty to do so; but when he tells others that there is no other well in the world, men think that his world is very small. So mathematicians, having found that if the teeth of bevel gear taper in all of their proportions to a single *point*, they may run with relatively equal speeds in all of their corresponding parts, and make theoretically perfect work; so far they say true; but when they say that such gear are practically perfect, and further, that no other kind can be either theoretically or practically correct, they teach falsehood.

It is a quality of good generalship that enables the commander to use the means at hand; if his men have no powder he will close and use the bayonet. But mechanics let themselves become such slaves of habit that a man transferred from one turning engine to another will make that fact his excuse for inferior work.

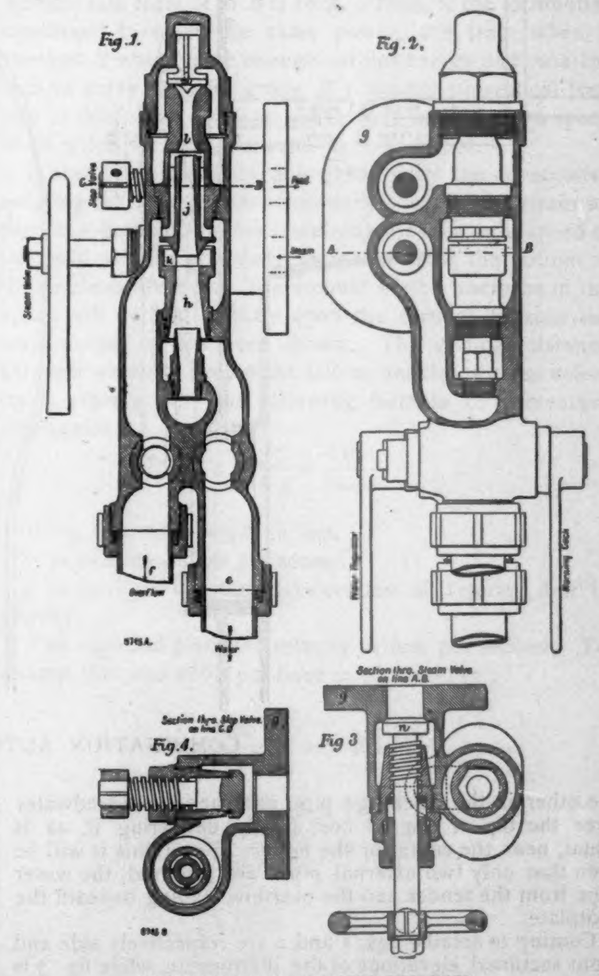
When a mechanic learns that good work is good work; that the intrinsic value of a result is not to be gauged by *who* or *what* contributed thereto, he is educated beyond the average, and may attain to that degree of intelligence that he may understand that the various curves mentioned above are not to be represented by portions of circles any more than a circle, or themselves for that matter, are to be represented by a series of straight lines. The man who would run a polygonal journal in a polygonal bearing as "an approximation," in place of a circular journal in a circular bearing, would show fully as much sense as the man who makes gear teeth with portions of circles, or with cycloids or involutes, or any other poor approximation.

When the mechanical world, finding that such results are attainable without difficulty, demands gear that run as close, smooth, noiseless, and perfect in all their action as a fine-fitted circular journal in a circular bearing, then mechanics will make such gear, and those gear teeth will be Hypercycloidal.

ALOHA VIVARTTAS.

Gresham & Craven's Combination Automatic Injector.

THE accompanying engravings, figs. 1, 2, 3, and 4, which, with the description, are taken from *Engineering*, illustrate the most recent form of what is called the combination automatic injector, manufactured by Gresham & Craven, of Manchester, England, and figs. 5 and 6 show the method which has been adopted by Mr. Francis R. F.

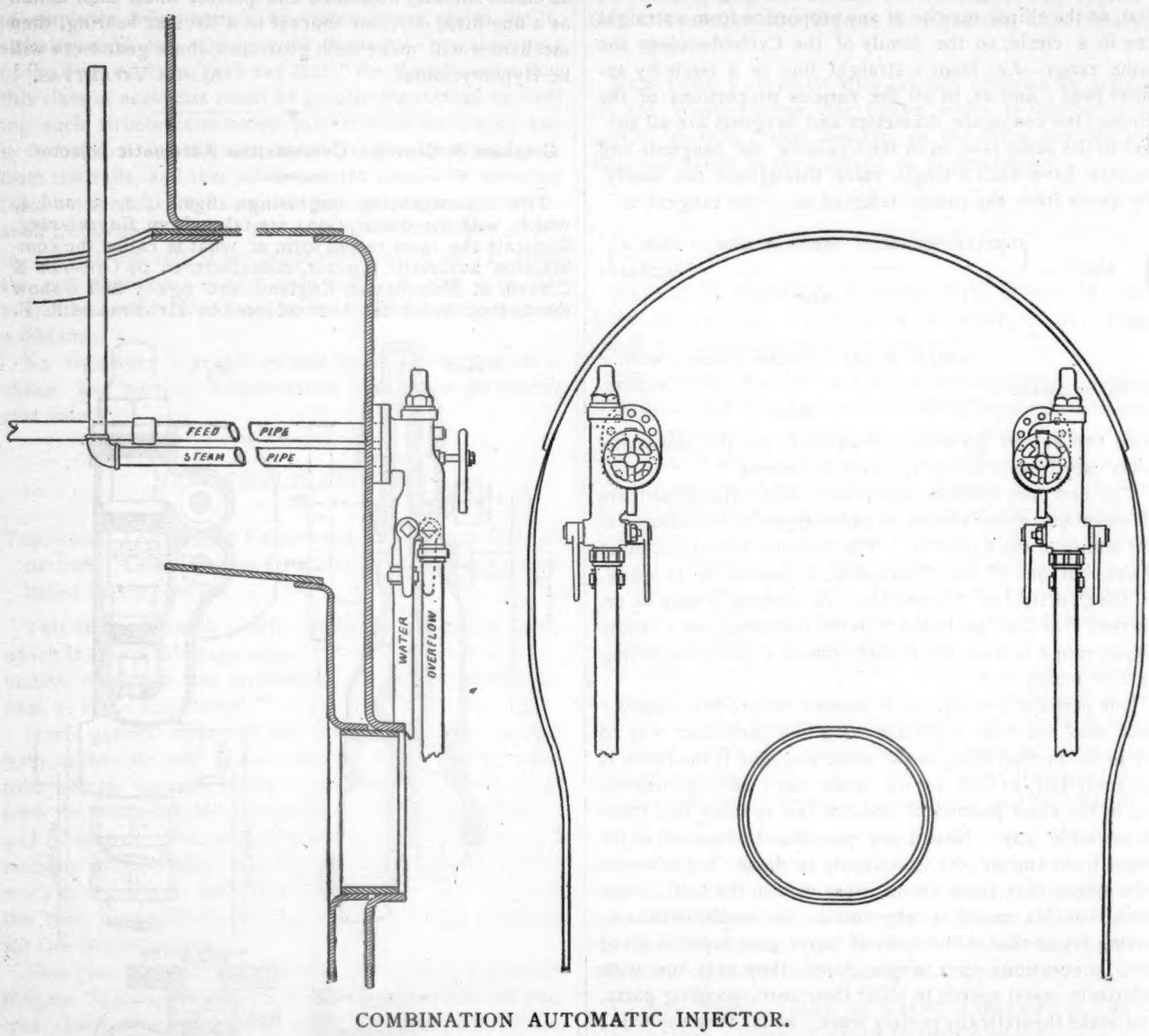


COMBINATION AUTOMATIC INJECTOR.

Brown, Mechanical Superintendent of the Canadian Pacific Railway, in applying it on that road. It will be seen from the illustrations that openings have only to be made at one place in the boiler, and the instrument is complete in it-

self, being provided with, as its name implies, all the necessary valves, viz., a steam valve, a back-pressure valve, a stop valve, a water valve, and a warning cock; it nevertheless barely exceeds in size and weight the common type of injector. With injectors previously introduced it has been found necessary, when they were to be used as lifting injectors, to fit them with a needle-shaped spindle for the purpose of adjusting the steam when lifting the water, and they have not, therefore, been commonly adopted on locomotives. With the new injector this spindle has been dispensed with, and the instrument is fitted at a level above that of the water in the tender to the back of the fire-box, through which holes are drilled for the insertion of two tubes of 1½ in. internal diameter, both carried inside the boiler. One of these leads to the dome, and through it is taken the steam supply to the injector, while the footplate. To work the injector the fireman simply opens the valve *N* full, when the steam blows through the lower or fixed part of the combining cone *h*, creating a vacuum in the waste pipe by induction and passing out through the overflow. When the water lifted by this vacuum meets the steam, condensation takes place, and the upper or moving part of the combining cone *j* then falls on to its seat and becomes substantially part of the fixed cone *h*, being held firmly in position by the vacuum created by the inductive action of the combined jet of steam and water in passing the opening at *k*. This jet finally passes up the throat *l*, raises the back-pressure valve *m*, and passes into the boiler.

Figs. 5 and 6 show the method of attaching the injectors to the back end of the fire-box. It will be seen that there are no external pipes excepting the supply pipe *A*, fig. 5,



COMBINATION AUTOMATIC INJECTOR.

the other is the discharge pipe and carries the feedwater over the top of the fire-box, finally delivering it, as is usual, near the center of the boiler. From this it will be seen that only two external pipes are required, the water pipe from the tender and the overflow leading beneath the footplate.

Coming to details, figs. 1 and 2 are respectively side and front sectional elevations of the instrument, while fig. 3 is a cross-section through the steam valve on the line *A B*, and fig. 4 is a similar view through the stop valve on the line *C D*. The injector is attached to the boiler by the flange *g*. The water branch *e* is connected in the usual way to the tender, by 1½ in. pipe, while the overflow branch *f* is connected with a pipe of the same size leading below

and overflow pipe *B*. This makes it possible to put these pipes entirely out of sight, and also gets rid of the danger of knocking off the check-valves in case of accident, which, it will be remembered, occurred in one case in Pittsburgh on the Pennsylvania Railroad some years ago, by which a whole car full of passengers were horribly scalded. Other accidents of a similar character have occurred on other roads, so that the danger is one which ought to be guarded against. There will also be considerable saving in copper pipe and labor thereon, and very little danger from freezing.

Mr. Brown is the first person who has applied injectors in this way to American engines. His example is worthy of imitation in this country.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

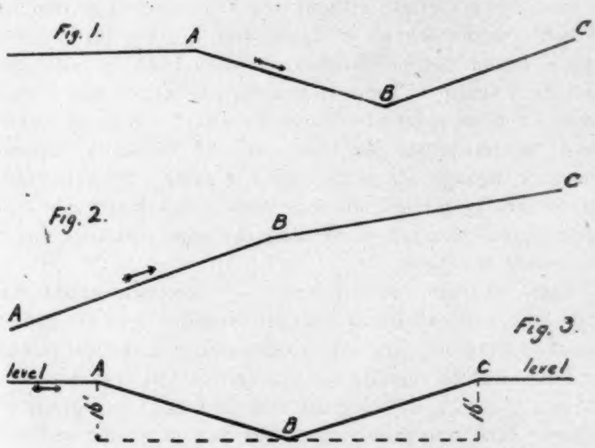
(*Continued from page* 301.)

CHAPTER XXVII.

REDUCING THE VIRTUAL GRADE BY MEANS OF MOMENTUM.

In establishing any system of grades upon a section of railroad to be built, the engineer must always bear in mind the fact that, when the different grades are so situated in regard to each other that a train passing over them can acquire a greater velocity than its normal speed, without developing any extra power in the locomotive, this surplus velocity can be used and will be used in the shape of momentum to help the train up the next grade, and that therefore the grade will be reduced, in regard to the power exerted by the locomotive, by just the number of vertical feet through which the momentum alone would lift the train. All the resistances to the movement of a train, with the exception of that due to the force of gravity on the inclined plane of the grade, may be left out of the question

PLATE XLIX.



entirely, as they are overcome by the power exerted by the locomotive.

All these resistances, such as internal friction, rolling friction, etc., due to any speed, are overcome by the locomotive when the train is running on a level, and if the locomotive continues to exert the same power they will be exactly overcome on a grade, and the only additional resistance is that due to the force of gravity alone or the amount of force necessary to lift the train vertically the total number of vertical feet surmounted by the grade.

To present the idea in a clearer manner: Suppose two grades come together in the manner shown in fig. 1, Plate XLIX. Let the train be running in the direction of the arrow. Suppose the train is running at a speed of 30 miles per hour when it strikes the down grade *A B*. If the locomotive continues to exert the same power that it did on the level track preceding *A B*, then in running down *A B* the speed of the train will increase in proportion to the number of vertical feet fall from *A* to *B*, and when the train reaches *B* it will have acquired a certain surplus velocity over and above its normal speed, and this surplus velocity is stored up in the train in the shape of power, which may be used to assist the train up the grade *B C*. Or in common parlance, the grades *A B* and *B C* are relatively so situated that it is possible to get a run at them and thus virtually reduce their height.

Suppose the two grades were situated as in Plate XLIX, fig. 2. In that case it would be impossible to get any run at the grade *B C* without increasing the amount of power exerted by the locomotive on a level, and the result would be either one of two things: the amount of power exerted by the locomotive must be increased or the speed of the train must be decreased.

To return to the question of storing up power by allowing the speed to increase in running down grade: The amount of power stored up at the foot of the grade will exactly equal the amount which the train would have if it had been dropped through the same vertical distance, and its speed or velocity at the foot of the grade will be the same as that which would be acquired by a body falling the total height of the grade. Starting with the normal rate of speed at which the train would run on a level with a locomotive exerting the same power, this stored up power will carry the train up the following grade exactly the same number of vertical feet. In Plate XLIX, fig. 3, suppose a train running in the direction of the arrow has a speed of 30 miles per hour when it reaches *A* and the vertical fall from *A* to *B* is 16 ft. Then, if the locomotive continued to exert the same power, the train when it reached *B* would have enough surplus energy and momentum to carry it up the grade *B C* exactly 16 vertical feet, and at this point, or 16 ft. above *B*, it would have a speed of 30 miles per hour, the same as it had at *A*.

If the train descends any grade with the locomotive exerting the same power continually—that is, the strain on the draw-bars or couplers remaining constant—the speed of the train will be gradually increased until the bottom of the grade is reached. The amount of this increase in the speed will depend directly upon the vertical distance the train drops, as has been shown. The vertical distance through which a body must fall to acquire a given velocity is expressed by the following formula of elementary mechanics:

$$h = \frac{v^2}{2\,g} = \frac{v^2}{64.32}.$$

Here, h = total height in feet.
v = velocity in feet per second
$g = 32.16$ = constant acceleration of velocity due to gravity.

This equation gives the velocity in feet per second. To change this into miles per hour $= V$, we have:

$$v = \frac{5280}{60 \times 60} V = 1.466\, V,$$

$$h = \frac{\left(\frac{5280}{60 \times 60}\right)^2 V^2}{64.32} = \frac{2.15\, V^2}{64.32},$$

$$v = \frac{\sqrt{h\, 64.32}}{1.466}.$$

By this last formula we are enabled to calculate at once what the speed of any train would be at the bottom of any grade; and therefore know exactly how much surplus power, over and above the normal speed, is stored up in the train and available for use in surmounting the next

grade or running on a level with a diminished amount of power exerted by the locomotive.

There is a limit beyond which momentum grades cannot be used. This limit arises from the fact that there is a limit to the speed at which it is safe to run a train. When, in running down any grade, this point of safe speed is reached, any increase above it is prevented, first by shutting off the steam in the cylinders, and thus reducing the power exerted by the locomotive to nothing, and next, if the friction and resistance to motion is not sufficient to counterbalance the constant acceleration due to the incline, this resistance is increased by the application of the brakes until such a point is reached that the resistance due to the brakes (the friction between the brakeshoe and the rim of the wheel) plus the normal resistance to motion, is exactly equal to the amount of acceleration due to the incline. Under these conditions, the train will continue to move at exactly the same rate of speed over the remainder of the grade. As will be readily understood, the effect of these undulating grades is much greater upon freight trains than upon express trains, because the allowable maximum of speed is much greater in the express than in the freight, so that the constant acceleration of velocity on a down grade can be taken advantage of to a much greater extent than in a freight train, and also from the fact that, the normal rate of speed being much higher in the express than in the freight, any absolute differences in the rate of speed bear a much smaller proportion to the normal rate.

Thus, an express train running at the rate of 50 miles an hour encounters an up grade of 50 ft. rise. At 50 miles per hour the train has velocity enough to lift it 83.61 vertical feet; consequently, at the top of the grade it still has velocity sufficient to lift it 33.61 ft., which, by the above formula, we find equals a speed of a little over 30 miles per hour, while a freight train moving even at a velocity of 39 miles per hour would be at a standstill at the top of the grade, or, at least, only moving at a rate of 0.87 miles per hour. Now, 39 miles per hour is much greater than the allowable maximum speed of freight trains, which should never exceed 30 miles per hour. In establishing grades so that they may be conducive to the greatest economy in regard to taking advantage of accelerated speed, they should, when possible, never have so great a vertical fall as to require the use of brakes, nor so great a rise as to reduce the speed of freight trains below 10 miles per hour, as at this speed any slight variations in the circumstances under which the train is run will at once reduce this rate to zero and stall the train.

In considering the effect of grades upon the speed of trains as to increase or decrease, we have, as stated in the beginning, omitted entirely from the calculation all effect due to the resistance to motion of the train resulting from the many elements of friction always present.

All this resistance we have supposed to be overcome by the power exerted by the locomotive, and if the locomotive continued to exert this power constantly no allowance for this friction need be made; but, when running down grade the acceleration due to the grade soon does away with the necessity of any power being exerted by the locomotive. This is particularly the case with freight trains, where, as has been said, the increase in speed due to any given fall in grade bears a much larger proportion to the normal rate than in the case of an express train. The first thing, therefore, that is done on these grades in running down is to shut off all steam from the cylinders and thus do away with all tractive power. Under these circumstances, part of the force of gravity is used up in overcoming the normal resistance to motion of the train. We have considered this resistance to motion at 9 lbs. per ton. This is the resistance of the train behind the locomotive; in the present case, we have also to consider the resistance to motion in the locomotive itself considered as a car. The resistance to motion in a locomotive has been found to be from 15 to 20 lbs. per ton, depending upon the class of locomotive used. Taking this in connection with the 9 lbs. per ton due to the train, we can call the total resistance to motion in a train, including the locomotive, 10 lbs. per ton. Now, 10 lbs. per ton resistance in a train equals a grade rising 0.5 ft. per 100 ft., or a grade of 0.5 per cent. This grade is called the GRADE OF REPOSE—that is, the grade having such an inclination, that if a train is started down it at a given rate of speed it will continue running at that same rate, no faster, no slower, the whole length of the grade. The inclination of the grade of repose will vary with the initial velocity of the train, and the resistance it offers to motion. Now, it is to be noted that this grade of repose is not the grade upon which a train at a standstill, if left to itself, will start, but much less than that grade is. The resistance which must be allowed in starting a train from a state of rest is very much more than that encountered in keeping it in motion after it has once started. In running a train down a grade without steam the amount of velocity which it would acquire in descending a given vertical distance would not be as much as when running with just sufficient steam to keep up the normal rate of speed on a level; and, in order to find exactly what the velocity would be at any particular point, we use, not the actual vertical distance through which the train has passed, but this vertical distance less the amount of vertical fall the train would have passed through in running the same distance down the grade of repose.

Thus: A train running down a 1 per cent. grade one mile long, with all steam shut off, would not at the end of the mile have acquired the velocity due to a vertical fall of 52.8 ft. But the velocity due to a vertical fall of 52.8 — 26.4 = 26.4 ft.; 26.4 ft. being the vertical height in a grade of 0.5 per cent. one mile long or the rate of grade we have taken as the "grade of repose." In calculating the effect of grades upon the running of trains, the engineer must never fail to take into consideration this question of the grade of repose.

There is also another question which must be considered in the establishment of grades at stations or other points where there will be a stop. The conditions are as follows: When a train is started from a state of rest, the velocity at which it moves commences at nothing, and gradually increases until, within a certain defined distance, it must be the normal speed at which the train is run. To run a train at any uniform speed, there is required a certain expenditure of power by the locomotive, and to increase this rate of speed requires a corresponding increase in the power exerted, and this increase has the same effect upon the movement of the train that an up-grade of a certain rate and length would have. Suppose it is required to start a passenger train and so increase the speed that at a distance of 2,000 ft. from the starting-point it shall have a speed of 30 miles per hour. The extra amount of power which would have to be exerted would be the same that would be required to surmount a grade, the vertical rise of which in the 2,000 ft. would be the same as the distance through

which the train would have to drop to acquire the given velocity of 30 miles per hour; and, according to the formula given, would be 30.1 ft., or a little more than a grade of 1.5 per cent. This would be the grade representing the extra amount of power due to the acceleration in the velocity of the train. To find the grade which shall represent the total amount of power required, we must add to this 1.5 per cent. grade the grade of repose, 0.5 per cent., making a total grade of 2 per cent. for 2,000 ft., which represents the amount of power required to start a passenger train, and in 2,000 ft. have it acquire a speed of 30 miles per hour; or, when the actual grade at a station is level, the virtual grade under the above conditions would be 2 per cent. In order, therefore, to obtain the virtual grade at the station, or the grade representing the relative amount of power expended, we must add this 2 per cent. grade to the actual grade. From this will be seen the great evil of so establishing the grade line that a stopping-place comes upon a comparatively steep grade or of introducing a steep grade upon a long uniform grade that works the locomotive to nearly its maximum power. A long uniform grade for surmounting any considerable height is for many reasons theoretically to be preferred; still, on account of the general configuration of the earth's surface, such long uniform grades are objectionable from a constructive standpoint, and, in relation to the operating expenses, necessitate more development; and the introduction of pieces of grade of a less rate is found very advantageous. They give the locomotive, as it were, an opportunity of taking a long breath, and, owing to the ever-increasing tendency to load the locomotive up to its maximum limit, these breaks in the grade, even at the cost of an increase in length and curvature, are often not only admissible, but desirable.

CHAPTER XXVIII.

VERTICAL CURVES.

In order to be able to take full advantage of momentum in surmounting grades, even when the grades are relatively established in a manner that makes this possible, the changes from one rate of grade to another should be made by means of vertical curves and not by the grades meeting at an angle.

In Plate L, fig. 1, let *A B* and *B C* represent two grades where the rate of grade changes directly from the one to the other. This would be very objectionable at any rate of speed at which the train might be run over it, but particularly so when the train is to be allowed to gain in velocity in running down *A B* in order to surmount *B C*. In order to obviate these objections, the angle *A B C* should be changed into the vertical curve *a b c d e f. . . . q*. The manner of establishing these vertical curves is explained later. The objections to the grades meeting, as shown in *A B C*, are as follows: The train running down *A B*, with the engine exerting a uniform amount of power, has its speed constantly and uniformly accelerated by the force of gravity. When the engine passes *B*, this same force of gravity acts against the power exerted by the locomotive and tends to decrease the speed, and as soon as each car passes *B* the same effect is produced. The consequence is that in any train, but more particularly in the cars of a long freight train, with a low nominal rate of speed, as soon as the engine passes *B* the speed begins to slacken in it and also in each car as soon as it has passed this point. Part of the train which is still coming down *A B* will therefore crowd on the front of the train at the point *B*, and the tendency will be to lift some of the cars off the track.

When about all the cars, however, have passed the point *B* they will be crowded together and the speed of the center ones will be very much reduced. At this point, the pressure from behind being removed, the engine will begin to take out the slack in the couplings between the cars. The speed of the engine will be increased as the resistance of the train will be less, and the consequence will be that the train will lengthen out quickly and cause an excessive strain to come suddenly upon the couplings, which is often more than they can bear, and the train breaks apart.

There are two methods by means of which these objections may be overcome to some extent when vertical curves have not been used in connecting grades of a different rate, or when they are too short:

1. By the application of the brakes to the rear car in running down the grade *A B*, in order that this car may act as a drag upon the train and prevent the crowding of the cars at the point *B*. This obviates the crowding of the cars, and the danger of derailment, to a certain extent, but it also counterbalances the advantages which might be gained in the shape of increased speed with which to surmount the grade *B C*, as this extra power is used up in overcoming the resistance occasioned by the application of the brake. Another evil attending this is the increased wear and tear in the rolling-stock, rails, etc., due to the application of the brakes.

2. By having the engine pull out—that is, increase its speed—as soon as it has passed *B*, so as to keep the cars running at practically the same speed up the grade *B C* that it did in coming down *A B*, thus preventing the crowding at *B* or the breaking apart of the train. The evil of this method is that the power exerted by the locomotive must be increased and also that when the last cars of the train have passed *B* there is the possibility of a sudden jerk on the couplers of sufficient strength to cause the breaking apart of the train. Much of this danger, due to the sudden taking up of the slack between the cars, may be avoided by the introduction of improved forms of couplers that do away to a great extent with this slack. With the present generally-used form of coupler on freight trains, the amount of slack is about 4 in. for each car, more or less, depending upon the amount of force that has been used to compress the springs; so that in a freight train of 60 cars it amounts to 20 ft., and the locomotive has attained considerable speed before the last car feels the effect at all.

The result of this, however, is done away with by the adoption of the Janney, or any of the many similar forms of automatic couplers. As yet neither the automatic coupler nor continuous freight-car brake are in general use, but everything tends to show that it is only a matter of a very short time before at least all through freights will be equipped with them.

One great objection that has been urged for many years against any kind of freight-car couplers that allowed very little play or slack has been that it would necessitate the reducing of the weight of the freight trains that could be hauled by the same engine, owing to the fact that much more power is needed to start a train than to keep it in motion after it is once started, and in a train with the link coupler the cars could all be backed together and started one after the other, taking advantage of the slack.

The jerk on the caboose is something tremendous in such a case, and often the link or pin fails in strength,

But by means of elaborate experiments at Burlington, Ia., conducted at the same time and in connection with the famous Brake Tests, it was fully demonstrated that not only could as heavy a train, but even a heavier one, be started with close couplers than with loose ones. With the close couplers the only slack to be taken up is that due to the compression of the springs, and although this in actual distance is very small, still the reaction taken in connection with it makes the train easier to start, and does away almost entirely with the sudden jerk on the last cars. But even with all these modern improvements there still exist many and serious objections to the meeting of two grades at an angle, particularly when the grades are in the relative position of *A B C*. This is much more objectionable, in this case, than when the grades are in the position *D E F*, as shown in Plate L, fig. 2. Here a train running in either direction has a strain upon all the draw-bars and there is no chance of the cars crowding.

Many of these objections or evils may, however, be done away with by the introduction of vertical curves—that is, by so rounding off the angle at which the grades meet that in the *length of the train* there is no change of grade sufficient to cause any practical change in the strain upon the draw-bars. But this change, if any, should be made so gradually that the effect will not be felt either in the train or in the locomotive.

By experience it has been found that when the change in the rate of grade is not greater than 0 05 ft. per station of 100 ft. all the more serious evils which have been mentioned are done away with.

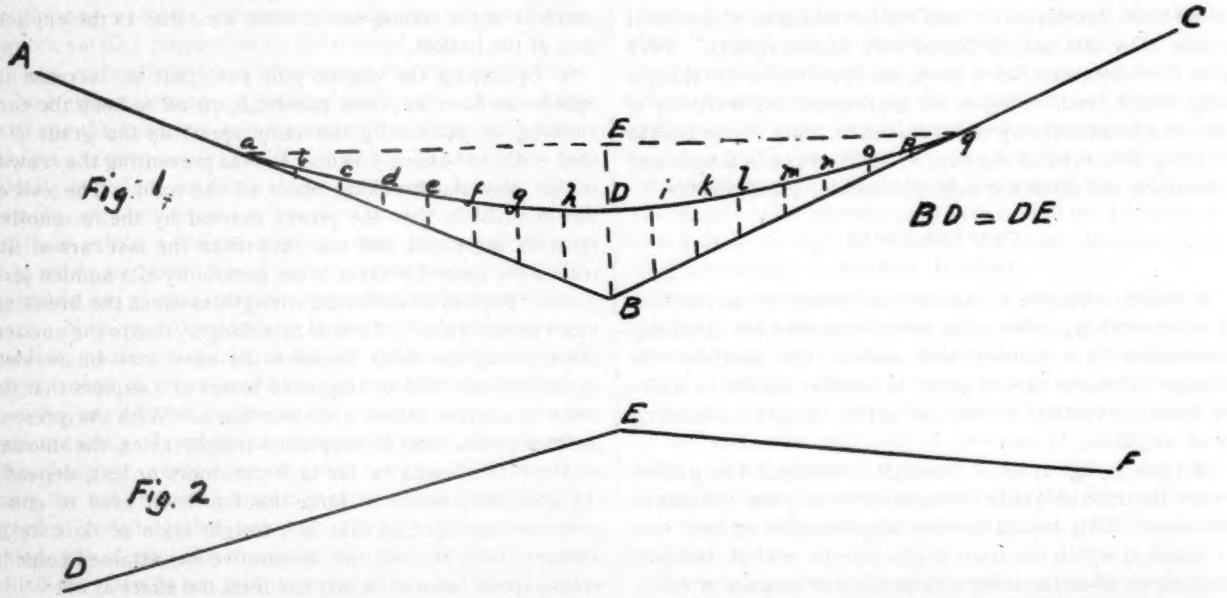
This amount of allowable change of grade depends upon the speed and length of the trains and, of course, varies as the circumstances vary. But as no change can be made in the track to correspond with the different trains, etc., some definite standard must be adopted which will apply to the average train and speed, and will also not materially increase the cost of construction, and a change per station of not more than 0.05 ft. fulfills the requirements. This is somewhat less, and makes the curve somewhat longer than the amount that is generally used; but it is none too small, especially before the general adoption of the automatic close coupler.

The method of staking out the vertical curve is as follows, the references being to Plate L, fig 1: Let *A B C* represent two grades meeting at *B*, each being a 0.4 per cent. grade. The total difference in rates is therefore $0.4 + 0.4 = 0.8$.

With an allowable change of rate of 0.05 per cent., the total length of the vertical curve would be $0.8 \div 0.05 = 16$ stations, or 8 stations each side of *B*.

Thus we have the stations at which the vertical curve begins and ends, the elevations of these stations commencing with station *a* for example, the elevation of which we will take as 100.00; then the elevation of station *d* would be $100 - (0.4 - \frac{.05}{2}) = 100 - 0.375 = 99.625$, the elevation of the first station, minus the rate of grade, less one-half the allowable change in grade, and the elevation of station *e* would be $99.625 - (0.4 - 0.075) = 99.625 - 0.325 = 99.30$, or the elevation of *d*, minus the rate of grade, less $1\frac{1}{2}$ times the allowable change in grade, and so on. The rate of grade for each succeeding station being less than the preceding one by the allowable amount of change in grade until the point *D* is reached, when from *D* to *C* the rate of grade increases per station to within one station of *C*, when the increase is only one-half as much in this last station in order to change from a curve to a tangent. The elevation of *C* will be the same as before the vertical curve was introduced.

PLATE L.



In order to check the work and also to calculate at once the greatest change that will be made in grade line by the introduction of vertical curves, the following formula will give at once the distance *D B*:

$$D B = \frac{A B + B C}{2} \times \frac{0.4 + 0.4}{4},$$

$$D B = \frac{(A B + B C) \times (0.8)}{8}.$$

$$A B + B C = \frac{0.8}{r},$$

$$D B = \frac{0.8^2}{8 r} = \frac{0.64}{0.4} = 1.6.$$

Or let L equal $A B = B C =$ total length of curve.

$\Delta = 0.4 + 0.4 =$ algebraic difference between the two rates of grade calling up and down grades in the same direction respectively plus and minus, and $r = 0.05 =$ allowable change of grade per station. Then we have

$$D B = \frac{\Delta^2}{8 r}.$$

This vertical curve will be a parabola from the fact that the stations are measured parallel to the grade and not horizontally. Thus, in Plate L, fig. 1, let *a b* represent a station. The length of this station, 100 ft., is measured on the line *a b*, and the rate of grade or the distance *A c* is the sine of the angle *A B C*, and not the tangent, as it would be if the stations were measured horizontally on the line *C B*. If *A C* was the tangent to the allowable angle of change in the grade per station, and was equal for each station, the vertical curve would be circular. From the fact that the curve *a b c d, etc.*, is parabolic the distance *B D* is always one-half *D E*.

(TO BE CONTINUED.)

TWIN LOCOMOTIVES.

FROM *Engineering* it is learned that "Messrs. Neilson & Co., Hydepark Locomotive Works, Glasgow, have completed a pair of twin locomotive engines and tender for the Indian State Railways (northwestern section). They are the first of the kind which Messrs. Neilson have constructed, and constitute part of an order of 20 engines and 10 tenders which the firm lately received from the Indian Government. The engines have outside cylinders with three pairs of coupled wheels placed between the cylinders and the fire-box. This allows the rigid wheel base to be the shortest possible. Between each two engines is placed a six-wheel double-ended tender, containing the fuel and water required by the two engines. Each engine is fitted with a powerful steam brake, which acts upon all the wheels, while the tender is furnished with a hand brake, which can be put in operation from either end. The leading dimensions of these engines and tenders are as follows: Diameter of cylinder, 19 in.; length of stroke, 26 in.; diameter of wheels, 4 ft. 2 in.; diameter of tender wheels, 3 ft. 7 in.; wheel base of each engine, 9 ft. 6 in.; wheel base of each tender, 9 ft. 6 in.; total wheel base of two engines and tender, 57 ft. 9 in.; total length over buffers, 80 ft.; contents of tender, 3,000 gallons of water and 8 tons of coal; weight of each engine loaded, 43 tons 11 cwt.; weight of each tender loaded, 40 tons 18 cwt.; total weight of combination, consisting of two engines and tender in working order, 128 tons. The engines are beautifully finished. They are to be employed in working the traffic on the heavy inclines on the Scinde-Pishin Railway, through the Bolan Pass."

As this is a somewhat new departure in locomotive practice, and one which seems to be very promising of good results where very powerful engines are required for working steep grades, engravings of a plan for twin locomotives described in an American patent granted to M. N. Forney, in 1882, may be of interest. Figs. 1 and 2 are copied from the patent referred to. Fig. 1 is a skeleton drawing of a pair of engines with the driving-wheels between the fire-box and smoke-box. *A A* are two trucks located under the foot-boards of the engines. They are arranged to support the overhanging weight of the fire-boxes and the two ends of the tender *T*. The overhanging weight of the smoke-boxes is carried on pony trucks *B B*. With this arrangement the truck under the foot-board serves to guide the engine which is running with the fire-box ahead, and a pony truck guides the other engine while it is running with the smoke-box ahead.

FIG. 1

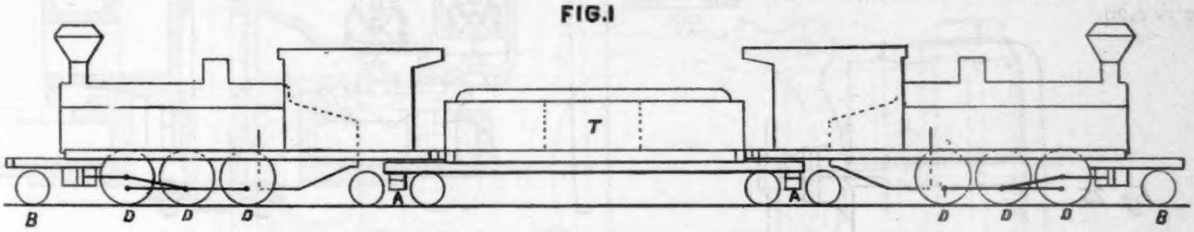
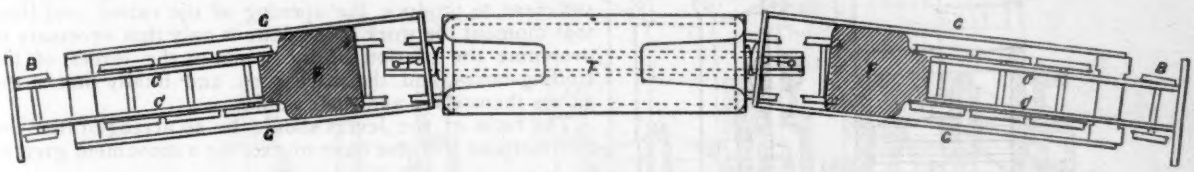


FIG. 2.



PROPOSED TWIN LOCOMOTIVE.

Fig. 2 represents a plan of the engine on a curved track. *F F* are the fire-boxes, which it will be seen are widened out beyond the outside of the wheels. The main frames *C C* are located in the usual way, with inside bearings, and abut against what is usually the front of the fire-box. Supplementary frames *G G* are then placed outside of the fire-box, wheels, and cylinders, and are fastened to the fire-box and cylinders. Heavy transverse beams—not shown in the engraving—are bolted to the top of the main frames and extend outward, and the ends of the beams are fastened to the supplementary frames. The tractive power of the engine is thus transmitted from the main frames by these beams to the supplementary frames, which are coupled to the tender. This permits of the use of a fire-box as wide as may be desired, which is not limited in depth, as it would be if placed above the frames or wheels of an engine. It also allows the bearings of the driving-boxes to be made of any length, as the main frames may be located in any position. Usually the frames of locomotives are placed as far apart as possible in order to give the greatest practicable width for the fire-box. With the plan described there is no object in doing this, as the width of the fire-box is not influenced by the distance between the main frames, and therefore they can be located centrally over the driving-boxes, whose bearings may be lengthened to double the usual dimensions.

In the patent referred to, the application of the same general principles of construction, to what may be called unitary locomotives, is described.

NOTES ON STEAM HAMMERS.

BY C. CHOMIENNE, ENGINEER.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 307.)

CHAPTER IX.

DISTRIBUTION OF STEAM.

FOR small hammers from 500 to 2,000 kilogrammes it is best to use the ordinary slide valves, as shown in fig. 25. This is the most simple and cheapest system; the pressure which must be exercised at the end of the lever to work the valve is represented by the formula

$$p = P \times \frac{l}{L} \times K.$$

P here represents the total pressure exercised on the valve; $\frac{l}{L}$ is the ratio of the levers or the distance traveled, and K is the coefficient of the friction of the valve on the face = 0.20.

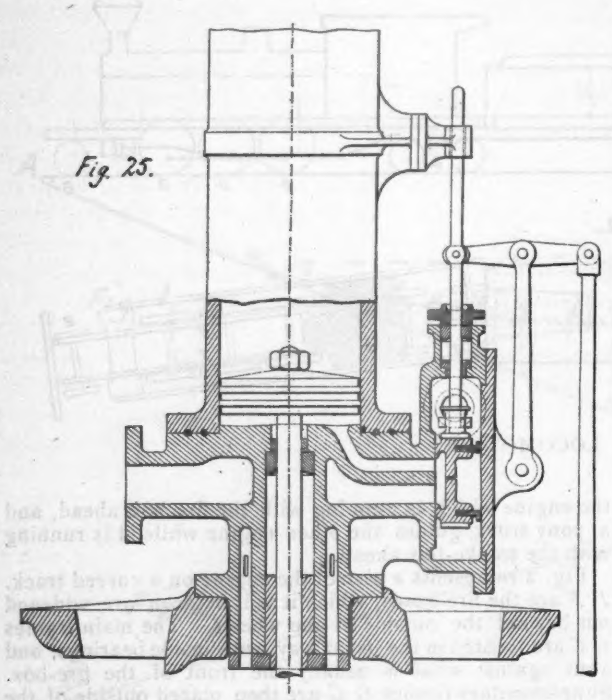


Fig. 25.

In any case, the pressure or work p should not exceed 12 to 15 kilogrammes.

For hammers over 2,000 kilos., two systems have been used: 1. Balanced valves with a double seat, as shown in fig. 26.

2. A circular or piston valve, as shown in fig. 27.

This last system has the advantage of being much more simple than the slide valve, and also permits the use of a heavier blow, the exhaust of the steam being much quicker than with the slide valve. It is also less subject to wear and derangement, and the leakage of steam is reduced to a minimum. The Works de l'Horme use this system for all hammers up to 50 tons.

In the case of distribution by slide valves, the lift should be equal to $\frac{1}{8}$ of the diameter, and the valves should have only a very small contact with their seats in order to secure the nearest possible equilibrium and to diminish the work necessary to move them. The contact in small valves should never exceed 8 millimeters, and for the largest 3 or 4 millimeters as a maximum. Fig. 33 represents the exhaust valve of the 80-ton hammer of the Steel Works of the Marine.

If we adopt the ratio of the levers $l : L :: 1 : 15$, and a pressure of steam of 5 kilometers, we have

$$p = S \times 5 \times \tfrac{1}{15}.$$

From this we have $p = 26$ kilos. to work the exhaust valve and $p = 18$ kilos. to work the steam valve. These

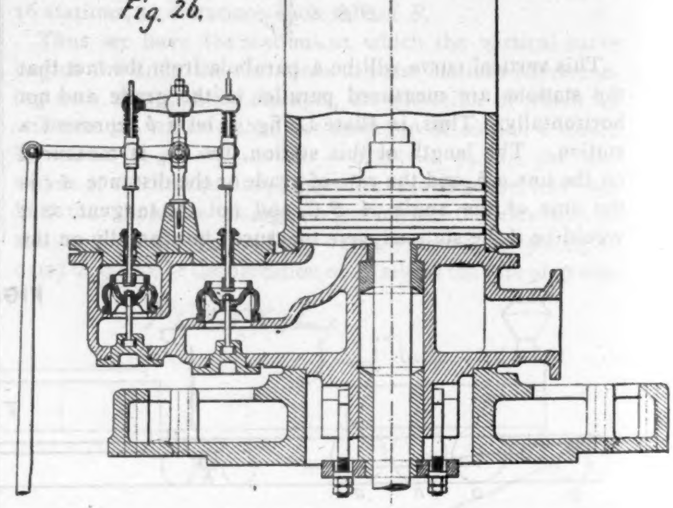


Fig. 26.

two figures represent the theoretic effort necessary to work these valves; but it is really much less, as a light shock is sufficient to produce the opening of the valves, and from that moment the work to be done is only that necessary to overcome the friction of the joints of the levers, of the stuffing-boxes, and the valve rods, and finally that of the valves themselves and their guides.

The ratio of the levers should be so arranged that the hammerman will not have to execute a movement greater

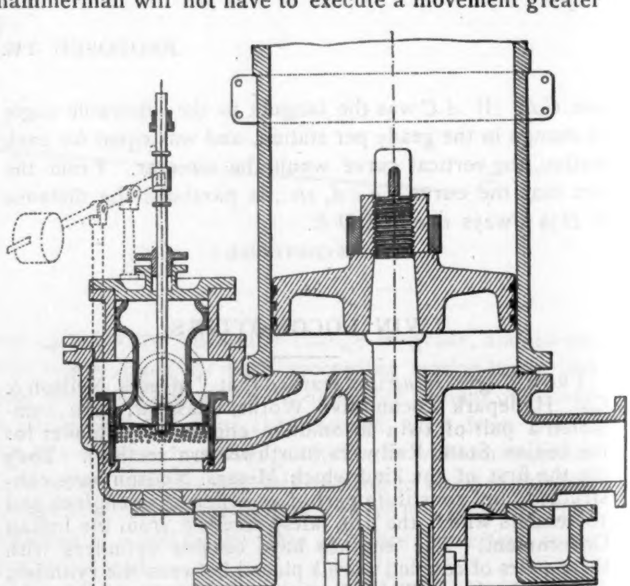


Fig. 27.

than 0.700 meter. In case of necessity two levers can be used, joined together by a stiff rod or handle and worked by two hammermen. In this way the work is divided in two parts, and the length of the movement can be diminished.

With a circular balanced valve or piston the work to be

done on the lever or hammer is only that required to overcome the friction of the joints of the levers, that of the stuffing-boxes, and finally of the segments of the piston in the cylinder. The only inconvenience arises from the lift of the valve, which is always much greater than that of the slide valve.

In general, in all the hammers used for forging parts of machinery or for stamping out large pieces, the distribution of steam is not automatic, but is made by hand, all

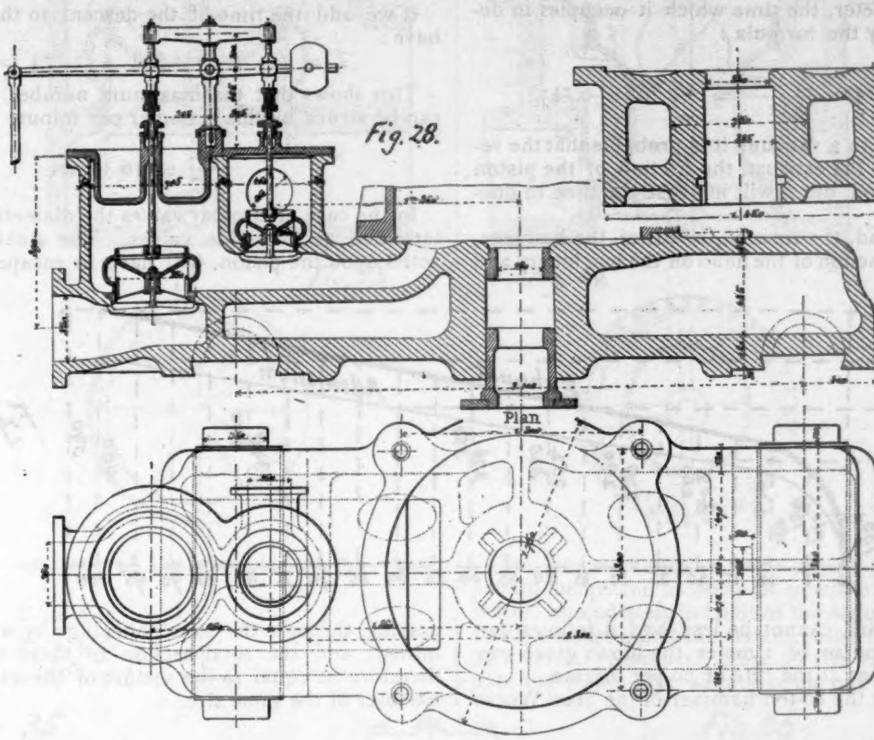


Fig. 28.

Plan

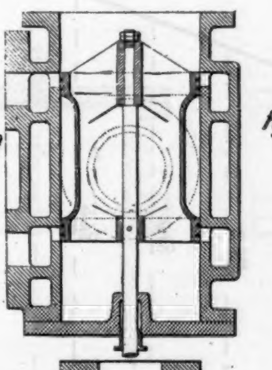


Fig. 29

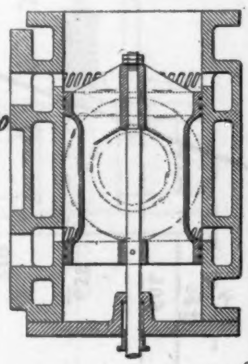


Fig. 30

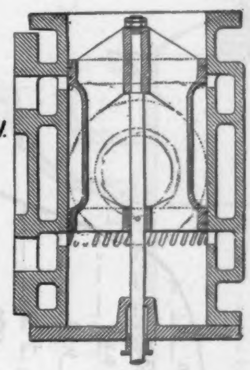


Fig. 31.

Fig. 32.

the inconveniences which could result from such an arrangement having been shown in practice.

In order that the hammer may be quickly and easily worked, the hammerman should have to make on the lever only a very slight pull and a short movement, while the steam and exhaust valves should have so large a section that the steam can act instantaneously on the piston and escape quickly into the air. We should then adopt as large openings as possible, whether we use slide valves or piston valves.

The diameters of the steam and exhaust pipes should have the same section as the corresponding ports, and the relation between the two sections should be not less than 1 : 1.5; that is to say, the exhaust valve should have a section at least equal to $1\frac{1}{2}$ times that of the steam valve, in order to diminish the counter-pressure, and to make the escape of steam into the air as easy as possible. The diagram accompanying—fig. 43—has been obtained by assuming: 1. An average steam pressure of 4 kilos.

2. A speed of admission of steam into the cylinder of 52 meters per second,

3. A speed of exhaust of steam into the atmosphere of 35 meters per second.

For higher pressures these dimensions may be reduced, and for lower pressures they should be increased.

In fig. 43 the ordinates represent the diameters which should be given the valves in millimeters; the abscissæ represent the power in tons of the different hammers; the heavy line corresponds with the exhaust valves and the fine lines with the steam valves. The minimum course of the hammer being 1 meter, the time which it occupies in descending is given by the formula:

$$t = \sqrt{\frac{2\,h}{g}} = \sqrt{\frac{2 \times 1.00}{9.81}} = \sqrt{0.20} \doteq 0.''45.$$

As this fall is not in a vacuum, it is probable that the resistance of steam to the exhaust, the friction of the piston and of the piston-rod, etc., will increase the time to one-half a second.

On the other hand, the time of the lift of the hammer, which includes the action of the hand on the machinery and the volume of steam which will reach the cylinder in a second under the piston will be

$$S \times V = 0.0962 \times 52.000 = 5.000 \text{ cub. met.}$$

Consequently, the time required to fill the cylinder will be:

$$t' = \frac{13.665}{5.000} = 2.''73.$$

If we add the time of the descent to that of the lift we have:

$$T = t + t' = 1.''04 + 2.''73 = 3.''77.$$

This shows that the maximum number of blows which can be struck by this hammer per minute will be:

$$\frac{60}{3.77} = 16 \text{ blows.}$$

In the case of circular valves the diameter should be determined as for slide valves. The steam, after having acted upon the piston, will have to escape into the air by

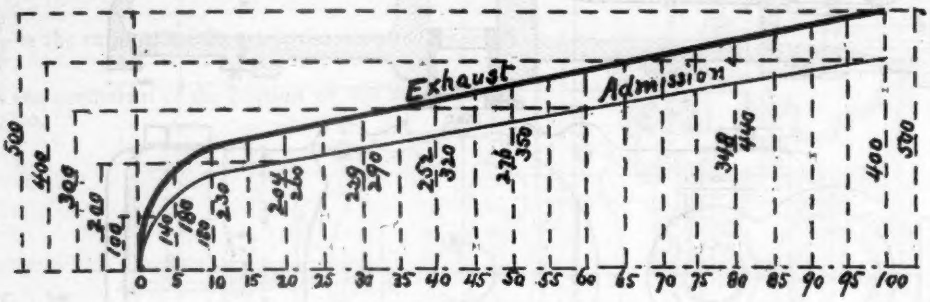


Fig. 43.

also that of the steam, cannot be less, and it follows that with a maximum course of 1 meter the blows given can only follow each other at the rate of 60 per minute.

If, again, we take the 80-ton hammer of the Steel Works passing through the same openings by which it was admitted, and the total section of these openings should therefore be equal to the section of the exhaust valve of a hammer of the same size.

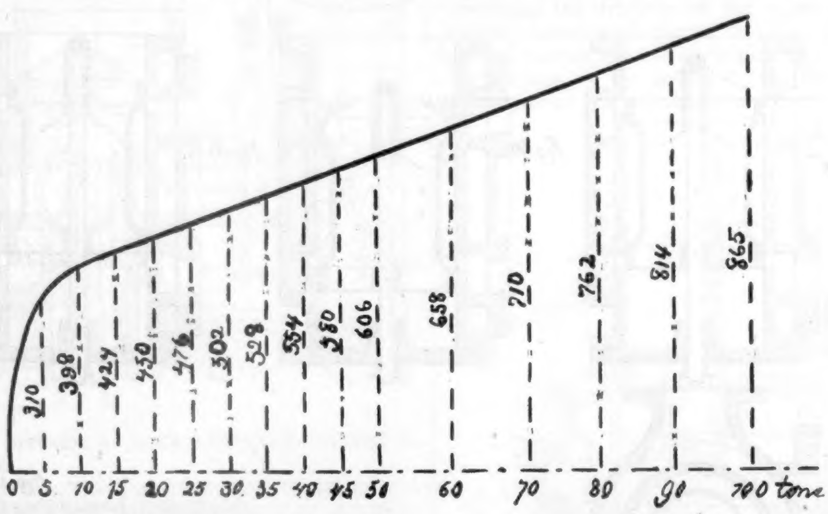


Fig. 44

of the Marine, whose fall is 5 meters, the time which the hammer takes in descending is:

$$t = \sqrt{\frac{2\,h}{g}} = \sqrt{\frac{2 \times 5.00}{9.81}} = 1.''04.$$

The volume of steam corresponding to this cylinder is:

$$\frac{D^2 - d^2}{1.273} \times h = \frac{1.900^2 - 0.360^2}{1.273} \times 5.000 = 13.665 \text{ cub. met.}$$

Here D is the diameter of the cylinder and d is that of the piston rod.

In assuming a speed of admission of steam of 52 meters per second and a steam valve of 0.350 meter in diameter,

Fig. 34 represents the design of a circular valve for a 50-ton hammer of Marrel Brothers.

Fig. 44 shows graphically the diameter of the circular valves of hammers whose power varies from 1 to 100 tons. It will be seen that above 50 tons the dimension and travel of the valves are so great, that it will be very useful to have them worked by a separate motor, or small auxiliary engine, in such a way as to reduce to a minimum the effort to be put forth by the hammerman.

In fig. 44 the ordinates represent the diameter to be given to the valves in millimeters; the abscissæ represent the power in tons of the different hammers.

The following formula may be used to find the diameter of a circular valve, the size of the exhaust valve of a hammer of the same power being known. Let D be the diam-

eter of the exhaust valve of the corresponding hammer; S the area of this valve; D' the diameter of the circular valve; L the circumference of this valve, and h the width of opening of the valve, which ought to be

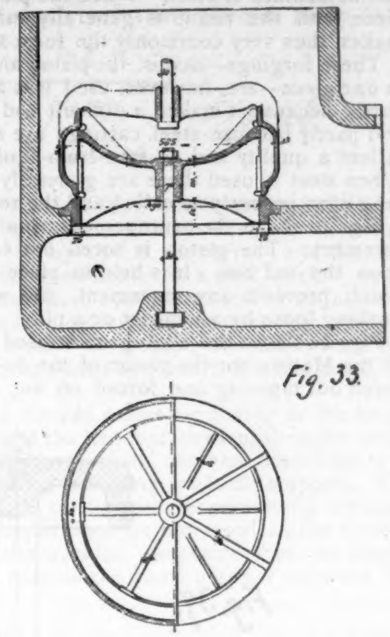


Fig. 33.

made equal to one-sixth of the diameter of the valve. Then:

$$L = 3.14 \times D'$$
$$h = \tfrac{1}{6} D'$$
$$3.14\, D' \times \tfrac{1}{6} D' = 2\, S$$

$$D'^2 = \frac{12\, S}{3.14} = 3.82\, S$$
$$D' = \sqrt{3.82\, S}$$

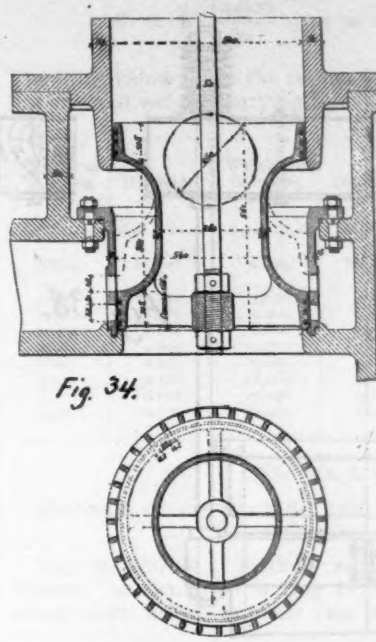


Fig. 34.

The steam admission valve should be balanced, and it should be placed as near as possible to the hammer, or better, immediately in front of the steam-chest, and should be so arranged that the hammerman can open or close it by a lever. Moreover, close to the valve or the exhaust port the steam pipe should open out into a reservoir of

Fig. 35

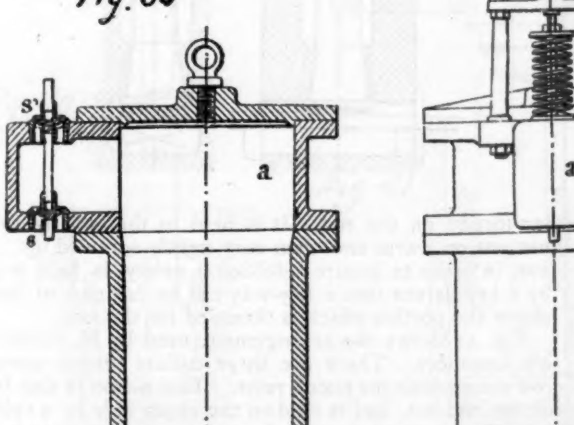


Fig. 36

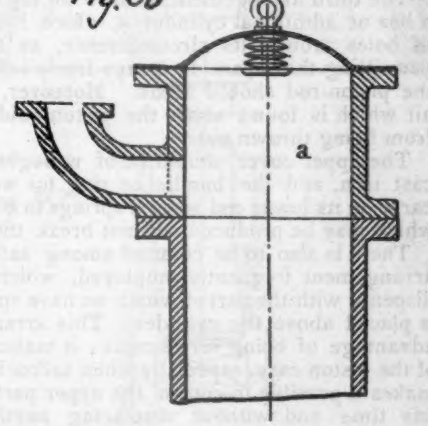
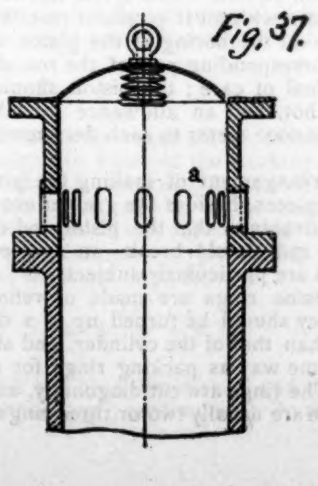


Fig. 37.



large dimensions in such a way as to give a very quick discharge and thus favor the descent of the hammer. This reservoir should then, by means of a pipe of large section, open directly into the air, and should have at its base a small pipe to permit the escape of condensed water.

CHAPTER X.

SAFETY APPARATUS.

There is often used a safety apparatus, which is shown in fig. 35: it is composed of a cylindrical part a placed above the cylinder and closed by a cover. This part a carries two valves; the one S below is free on its seat, and the upper S' is held to its seat by springs whose tension can be regulated at will. This upper valve permits the escape of compressed air. The piston in descending draws in the air from the outside through the valve S, and this air is compressed above the piston, in its ascending course, in such a way as to form a cushion, preventing any accident in the case of any breakage of the piston-rod;

moreover, its action is added to that of the hammer in a descending course.

This system, however, has never worked very well, and has gradually been abandoned by builders. Some have

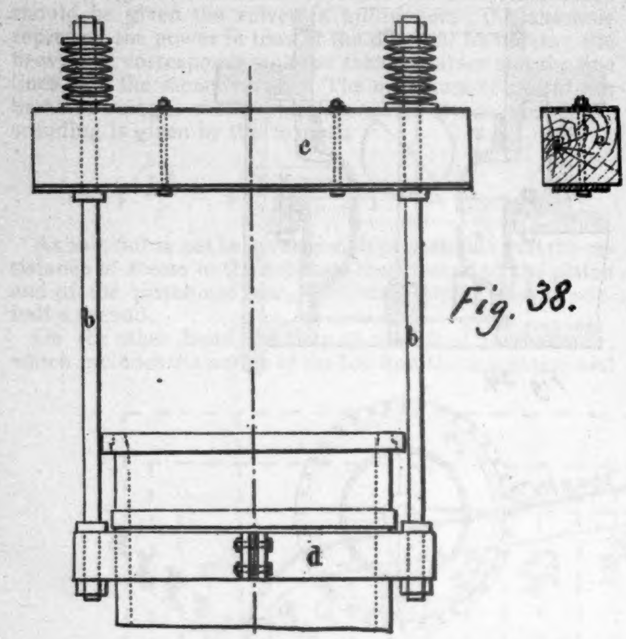


Fig. 38.

done away with the valves and have replaced them by a tube which serves to allow the steam to escape into the air should the piston-rod break, as shown in fig. 36, but the section of this tube is so small that it is not sufficient to permit the escape of the steam, and very often the piston strikes and breaks the upper cylinder-head. This system has also been generally abandoned.

The third arrangement is this: On top of the cylinder is a box or additional cylinder *a*, which has below a series of holes around its circumference, as shown in fig. 37, permitting the steam to escape freely into the air, in case the piston-rod should break. Moreover, the compressed air which is found above the piston holds it and keeps it from being thrown out.

The upper cover should be of wrought iron and not of cast iron, and the handle or ring for working it should carry on its lower end several springs in order that shocks which may be produced will not break the cylinder-head.

There is also to be counted among safety apparatus an arrangement frequently employed, which permits us to dispense with the part of which we have spoken, and which is placed above the cylinder. This arrangement has the advantage of being very simple; it makes the lubrication of the piston easy, especially when tallow is employed, and makes it possible to control the upper part of the piston at any time and without displacing anything. This apparatus is composed of an iron collar in two parts, tightly coupled together by bolts outside of the cylinder, and bearing against a ring cast on the cylinder. On this collar are fixed two bolts *b b*, which support a cross-bar *C*, of oak wood, protected above and below by heavy plates or channel irons. Above this cross-bar and held by the same bolts are several springs kept up by screws, as shown in fig. 38. The distance from the top of the cylinder to the wooden cross-bar should be equal to the length of the piston-rod below the piston, increased by 0.150 to 0.300 meter, in order to allow the steam to escape before the top of the piston strikes the cross-bar; in this way, there being no longer any pressure below the piston, the block has only to take up the shock resulting from the force of inertia of the moving parts. The diameter of the bolts *b* is calculated by the formula

$$d = \frac{D}{20} + 0.020.$$

In this *D* represents the diameter of the steam cylinder.

CHAPTER XI.

PISTON-RODS AND PISTONS.

The piston-rods and pistons are sometimes made of iron and sometimes of steel. When the piston is forged in one piece with the rod it is generally made of iron, and it makes then very commonly the form shown in fig. 39.

These forgings—that is, the piston and piston-rod forged in one piece—are, however, used less and less every year, partly because it makes a difficult and expensive forging, and partly because steel castings are now made of so excellent a quality and so free from faults and blow-holes. When steel is used there are generally two distinct parts, the piston properly so called and the rod.

Fig. 40 shows the arrangement usually adopted in small hammers. The piston is bored out tapering, and is put upon the rod hot. It is held in place by means of a nut, which prevents any movement, and which is kept from working loose by a jam-nut or a pin.

Fig. 41 shows the arrangement used in the Steel Works of the Marine for the piston of the 80-ton hammer; it is bored out tapering and forced on hot, and rests on a col-

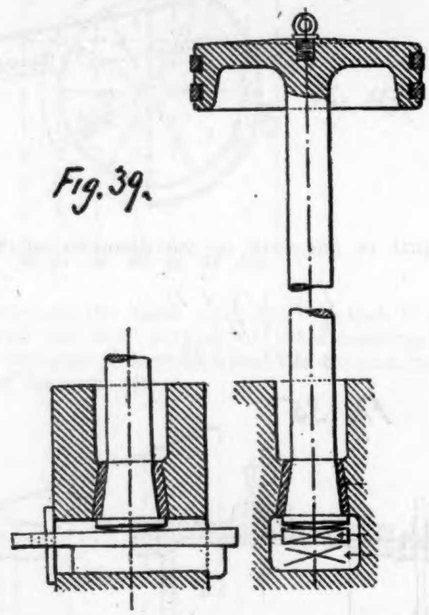


Fig. 39.

lar forged on the rod. It is held to the rod by a round nut put on warm and then very tightly screwed up. This nut, in order to secure additional safety, is held in place by a key driven into a key-way cut in the end of the rod above the portion which is threaded for the nut.

Fig. 42 shows the arrangement used by M. Arbel in all his hammers. There are three collars turned upon the rod upon which the piston rests. This piston is also forced on the rod hot, and is held on the upper side by a collar in two pieces, which is placed around a recess turned in the piston-rod, and is then held together by an outer ring or tire, driven on hot. This device has been used for a number of years with most excellent results.

In general the boring of the piston and the turning up of the corresponding part of the rod should be done with a great deal of care; the piston should always be put on the rod hot, and an allowance for shrinkage should be made of 0.0002 meter to each decimeter of the diameter of the rod.

The arrangement of making the piston and the rod in separate pieces, besides the greater economy, presents the further advantage that the piston-rod can still be used in case the rod should break—an accident to which large hammers are particularly subject.

The piston rings are made of refined iron or of mild steel; they should be turned up to a diameter somewhat greater than that of the cylinder, and should be sprung in in the same way as packing rings for ordinary steam-engines. The rings are cut diagonally, as from *a* to *b* in fig. 45. There are usually two or three rings on the piston, and

they should be put on so as to break joints in order to diminish the leakage of steam.

Many constructors now use steel for piston-rods. Until recently it was believed that mild steel was the best metal to resist shocks and vibrations. Steel, however, is a metal of many surprises, and recent experiments made in the

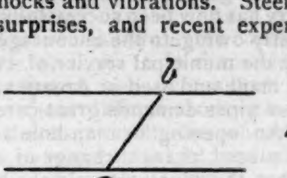


Fig. 45

United States by Mr. Metcalf, of the Crescent Steel Works near Pittsburgh, in connection with Professor Thurston, tend to show that this opinion is not correct, and that hard steel will resist vibrations better than mild steel.

These experiments have been continued by us in France on a number of rods annealed but not tempered, and with hammers varying from 1 to 10 tons; the results have fully confirmed the facts as stated by Messrs. Metcalf and Thurston.

The diameter of the rod varies according to the weight of the striking part of the hammer, the length of the stroke, the kind of metal to be worked, and also according to the temperature at which the forging is usually stopped. Consequently, the weight of the hammer remaining the same, the diameter of the rod must be increased as the stroke is increased and as the working temperature of the forging is lowered. The case is the same whetner we work iron or steel.

we have adopted a fixed ratio of 1 : 20 between the diameter and the length of the rod. Thus, in order to determine the diameter of the rod of a 10-ton hammer, we have

$$D = \sqrt{\frac{10.000}{60}} + 3 = 0.160 \text{ meter.}$$

The table below gives the results for the piston-rods of 24 hammers of weights varying from 1,000 to 100,000 kilos.

Weights of Working Parts.	Diameter.	Weights of Working Parts.	Diameter.	Weights of Working Parts.	Diameter.
Kilos.	Meter.	Kilos.	Meter.	Kilos.	Meter.
1,000	0.070	5,000	0.125	30,000	0.230
1,500	0.080	6,000	0.130	35,000	0.246
2,000	0.088	8,000	0.145	40,000	0.260
2,500	0.095	10,000	0.160	45,000	0.275
3,000	0.100	15,000	0.172	50,000	0.288
3,500	0.106	18,000	0.185	60,000	0.312
4,000	0.112	20,000	0.193	80,000	0.358
4,500	0.117	25,000	0.212	100,000	0.395

CHAPTER XII.

METHODS OF CONNECTING THE PISTON-ROD TO THE HAMMER.

Fig. 39 shows a method very generally adopted in France, consisting of a ring in two parts, made thicker above than below, in order that it may not slip upon the

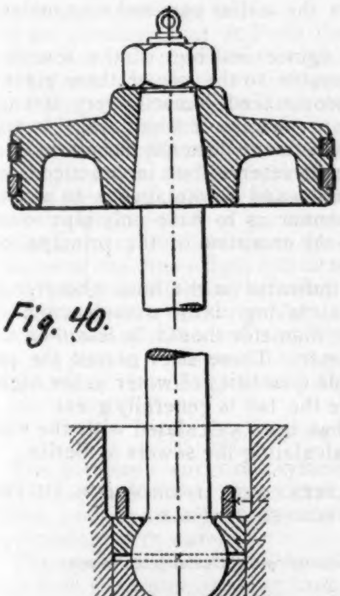


Fig. 40.

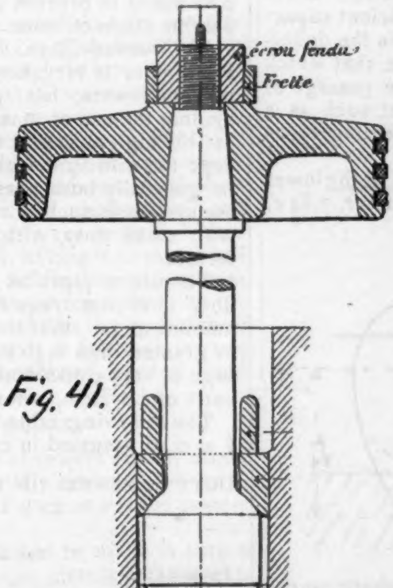


Fig. 41.

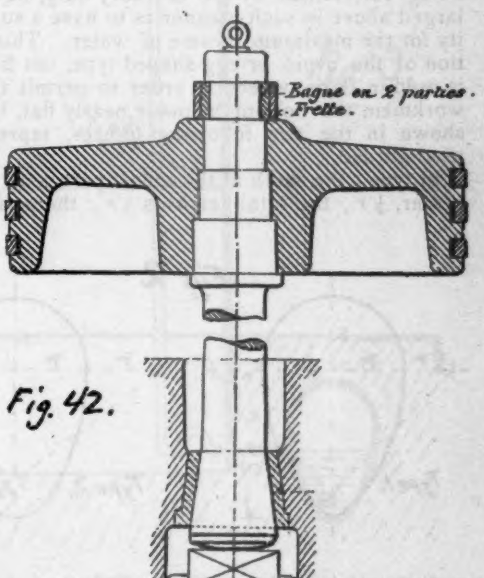


Fig. 42.

A practical formula for determining the diameter for the piston-rod of a single-acting hammer is as follows:

$$D = \sqrt{\frac{P}{K}} + 3.$$

Here D is the diameter required, in centimeters; P represents the weight in kilos. of the working parts, and K is a coefficient, which is taken usually at 60 for hammers from 1,000 to 15,000 kilos., and at 75 for hammers over 15,000 kilos. This formula is a variation of the formula used to determine the diameter of piston-rods for steam-engines, which, as we know, is as follows:

$$D = \sqrt{\frac{P}{K}} + 0.5.$$

The coefficient K has been diminished, and the constant has been raised from 0.5 to 3 centimeters. In this formula

rod. Once in place, the lower end of the rod carries a small collar holding this ring in the hammer-block. The rod is then fixed in position by means of a key and a counter-key strongly driven in, one against another, in such a way as to prevent any displacement.

Fig. 42 shows the method employed by M. Arbel; it differs from that just described only in having the ring upon the collar and not upon the rod.

This system of keying is that adopted by Bourdon, and is, after all, the only one which has so far given uniformly good results.

Fig. 40 shows the method generally adopted in England and Germany; it consists of a block or socket in which is placed the lower end of the rod, which is turned up in a spherical form, and of a ring above, which is made in two parts and held in place by two strong keys driven through the hammer-block. This system allows some variations in the position of the hammer without bending the rod,

but, on the other hand, it is not so readily used for stamping pieces of large diameter.

Fig. 41 represents the method adopted by the Société Cockerill at Seraing, Belgium, for large hammers. The lower part of the rod rests in two spherical pieces held together by a cylindrical ring. This arrangement has the advantage of being more easily made than the preceding one, and also of taking less material out of the hammer-blocks.

On the upper end of the piston-rod there should be a hole bored and tapped out, in which there should be screwed a stout ring; this will make it easy to lift or handle the piston when it is necessary.

(TO BE CONTINUED.)

NOTES ON THE SEWERAGE OF CITIES.

(Translated from paper of M. Daniel E. Mayer, Engineer, in the *Annales des Ponts et Chaussées.*)

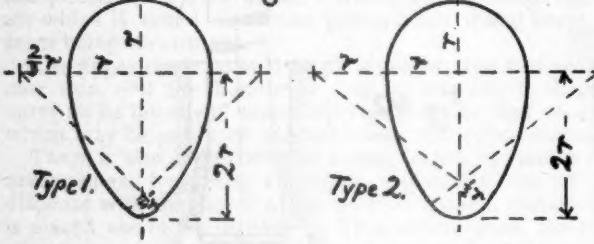
(*Continued from page* 313.)

VI.—BEST SECTION FOR SEWERS.

As to the transverse section of sewers, considering the great variations in the value of Q, in the formula above, between the ordinary and the maximum duty, the conclusion which we have drawn from these formulæ is that the best section is one having a circular form, the diameter being determined by the ordinary duty, but which is enlarged above in such manner as to have a sufficient capacity for the maximum volume of water. This is the definition of the ovoid or egg-shaped type, not like that which is used in Paris, where, in order to permit the passage of workmen, the bottom is made nearly flat, but such as is shown in the two following figures, representing types used abroad.

In type 1 the width at the widest part is $2r$; at the lower center, $\frac{1}{2}r$; the total height is $3r$; the perimeter, $7.84r$,

Fig. 2



and the total section, $4.46r^2$. The total discharging capacity (full) is:

$$\frac{3.363}{\sqrt{b}}\sqrt{r^5 I} = 5.80\sqrt{r^5 I}$$

when $b = 0.33$

For type 2, the width at the widest part is $2r$; at the lower center it is r; the height is $3r$; the perimeter is $7.93r$, and the total section is $4.594r^2$. The total capacity (full) is:

$$\frac{3.494}{\sqrt{b}}\sqrt{r^2 I} = 6\sqrt{r^2 I}$$

when $b = 0.33$.

Type 1 is most used, but type 2 has the advantage of a narrower base, and consequently is better suited for those cases where the ordinary duty represents only a small proportion of the total capacity which may be required. These oval, or rather ovoid, forms are theoretically best for large sewers with a variable duty, but in practice we should not hesitate to employ for small sewers circular pipes of glazed clay or stoneware, which, from their many excellent qualities—strength, smoothness of surface, resistance to the acids which are often contained in sewage water, cheapness of first cost and of maintenance, ease of cleaning, etc.—are in our opinion the very best.

Until lately this class of pipes was made only in England, but the industry has now been successfully established in France, particularly owing to the encouragement given for several years by the municipal service of Paris. They are also extensively made and used in America.

The laying of these pipes demands great care in placing and in the joints. An opening or man-hole accessible to workmen should be placed at each change of direction or fall in such a way that the pipes may always be placed in proper line and that changes may be properly marked. This class of sewers is particularly adapted to straight and regular streets; it would be more difficult to apply in narrow and crooked streets.

For larger streets an excellent solution has been adopted in Berlin, where four-fifths of the sewers are of the earthenware pipes; this is to place two in each street, one under each sidewalk. This arrangement avoids the necessity of disturbing the roadway and reduces very much the length of the house connections, which can also be given sufficient fall to keep them clear, even when the sewer, as is often found necessary in so flat a place, is very near the surface of the ground.

Experience shows that it would not be well to employ a pipe sewer, which receives house connections, of less than 0.24 meter in diameter; on the other hand, in most places there would be no economy in using pipes more than 0.50 meter in diameter in preference to a small ovoid sewer like those used in Frankfort-on-the-Main, which are 0.62 meter in breadth in the widest part and 0.93 meter in height, made of beton.

M. Durand-Claye, Engineer-in-Chief of the sewers of Paris, who is very favorable to the use of these pipes as public sewers, has pronounced himself very strongly against the use of masonry sewers of small size. In spite of this high authority experience does not permit us to accept the principle without reserve, but in practice it will be generally both possible and advantageous to arrange the system in such a manner as to have only pipe sewers with small duty, with the exception of the principal collectors.

The use of pipes as indicated is the best wherever the duty does not require, taking into consideration the amount of fall, that the diameter should be less than 0.24 or greater than 0.50 meter. These sizes permit the passage of very considerable quantities of water in the higher parts of a system, where the fall is generally great.

The following table has been calculated with the value $b = 0.40$, assumed in calculating the sewers at Berlin.

DUTY OF SEWERS (IN LITERS PER SECOND) FOR DIFFERENT DEGREES OF FALL.

Diameter of Sewer.	Fall in meters per kilometer (1,000 meters).				
	20	15	10	5	1
Meters.	Liters.	Liters.	Liters.	Liters.	Liters.
0.24	78	69	55	39	17.5
0.27	105	92	74	53	23.5
0.30	137	120	97	68	30.6
0.33	174	152	123	87	39
0.36	216	189	153	108	48
0 39	264	231	187	132	59
0.42	317	278	224	150	71
0.45	377	331	267	189	84
0.48	443	389	313	222	99
0.51	516	352	365	258	115

The fall of 1 in 10, which is greater than any known in Berlin, can be obtained in most of the cities of France for pipe sewers, where the starting-point can be placed near the surface. With this fall a pipe of 0.50 meter in diameter will carry 0.365 cubic meter per second, which, adopting the calculation for rain water which we have given heretofore, corresponds to an area of 9 hectares served, or, if two-thirds of the area is in gardens, cultivated or unoccupied land, of 27 hectares. This surface will be much more increased if we adopt the system just mentioned of two sewers in each street.

It may be assumed then that the greater part of the system of city sewers may be made of these pipes, and that it will be only for the heavy duties required of the collecting or main sewers that the building of masonry sewers will become necessary.

At Frankfort-on-the-Main the ovoid pipes of type 2 shown above, of 0.93 : 0.62 diameter, form the greater part of the system, and, as has been proved, they can be kept clean without difficulty and with small expense.

It is not the same at Berlin, where there are masonry sewers of 0.90 meter in height, and where the fall is very light; in spite of caution taken to prevent the accumulation of sand in sewers, it is rapidly deposited in these galleries, and it is necessary that workmen enter the sewers to clean them out; which, in so small a passage-way, is extremely difficult and unpleasant work. The same inconvenience due to sand is present in pipe sewers, but results in less trouble, for in these it is sufficient to use brushes, drawn through the pipes by cords, where the pipes show a tendency to fill up.

Fortunately, however, the unfavorable conditions found at Berlin--this almost entire lack of fall—are very rarely found in French cities.

A general collecting sewer of type 1, of 2.00 : 1.66 diameter, with a fall of 1 millimeter to a meter and full only up to the widest part, will carry off 170 cubic meters per second; this is more than three times the ordinary duty of a city of 150,000 people. We may adopt these dimensions in a city of 100,000 people, even where population is increasing with some rapidity, and a work of this size will carry off easily not only the dirty water, but also the overflow from the average rains.

If we consider that at Paris the smallest type actually used in the less important streets is 2.30 meters high, it will be seen that, without disapproving the conclusions of the Parisian service, it will be best to warn other cities against imitating this example.

The general collecting sewers of very great size, like those existing in Paris, are not required in other cities, even where the conditions of fall are so extremely unfavorable that an ordinary ovoid sewer of 3 : 2 meters in diameter will not suffice to carry off three times the ordinary amount. Now a sewer of the dimensions indicated, having 0.40 meter fall per kilometer, will carry off when full to the widest part 2.5 cubic meters per second, which corresponds to an ordinary duty of 0.800 cubic meter and to a population of 250,000 people. The conditions of fall in this case are not unfavorable, since $Q\ I^2 = 0.800 \times 0.40^2 = 0.128$, and $0.128 > 0.10$.

VII.—ACCESSORY WORKS.

The accessory works of a system of sewers are the street traps, the man-holes, works especially intended for ventilation, and the arrangements made to clean out the sewers by flushing with water.

The street traps or openings should be made in such a way that the water running from the streets and the gutters may flow into a sort of well or cistern, from which it passes into the sewer through a siphon. The use of the siphon here is not to prevent the escape of air from the sewer into the street, but to prevent the introduction into the sewer of solid bodies, which might obstruct it. In order to attain this object many different plans have been devised in England and Germany, but we do not think that any of them presents sufficient interest to require particular description.

Man-holes are vertical shafts large enough to permit the descent of workmen, and having a vertical axis meeting the horizontal axis of the sewer. By an arrangement of valves it is possible to fill one of these man-holes with water, and by opening them quickly to permit the accumulation of water to discharge itself into the sewer and produce a rapid current in the section immediately in front. These works—valves, gates, etc.—intended to clean out the sewers are comparatively small, and belong rather to the cost of maintenance than to that of construction.

VIII.—VENTILATION AND HOUSE CONNECTIONS.

A very important question is that of ventilation.

Is or is not the exchange of air between the sewers and the outer atmosphere to be avoided? This is a grave question, over which there has been much controversy, and upon which medical scientists do not yet possess precise information. While there is no doubt whatever that water carries germs of infection, and that the use of contaminated water either by man or by animals is very dangerous, we do not yet really understand the part played by the air in carrying these same germs, and we cannot actually see with how much danger the diffusion of the air of the sewers into the atmosphere is attended. Let us remark here that as to the exchange of air between the sewers and house, with its closed rooms, there is no discussion; such exchange should be prevented by siphons, both in the interest of the sewers and the house. We are now only speaking of the exchange of air between the sewers and the street.

If such exchange must be absolutely prohibited, we would be obliged to use for the flow of water passages made perfectly tight, and cleaned when necessary by mechanical means. Upon this principle have been founded several sys-

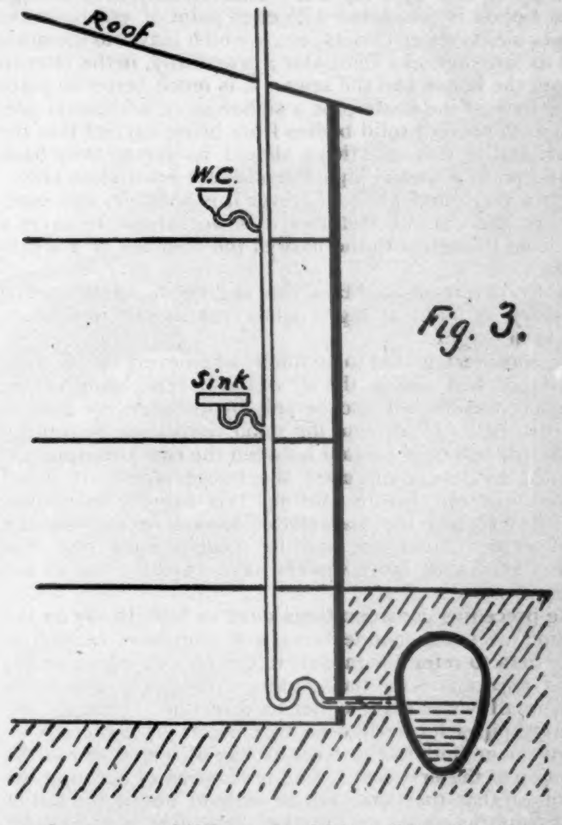


Fig. 3.

tems of sewerage of different kinds, but all based on the same principle, which we have called the separate system. Except in certain exceptional cases we have rejected this separate system, and on general principles we would continue to reject all forms of this system, in which an already difficult question is still further complicated with additional demands, which seem to us excessive and useless.

Whatever may be in fact the true theory of carrying the germs of infectious disease by the air, we believe it safe to assume that if proper measures have been taken to insure in the sewers a regular flow, and consequently to avoid all cause for stagnation and fermentation, there will be no danger in permitting connections between the sewers and the outside air.

This principle granted, it will be our part not to prevent but to develop, as far as possible, the communications between the sewers and the outside air. If the air of the sewer becomes confined and putrid it will have a bad effect on the branches into the house. Moreover, in a system where the smaller portions are obliged to receive much rain water, accidents are to be feared if the air of a sewer is not provided with sufficient escapes.

In the Parisian system ventilation is made possible through the street openings.

In the system which we have shown (fig. 1) the street openings are provided with siphons and can be counted upon for ventilation. The man-holes, if the covers are pierced with holes, may fill a useful part, principally to permit the escape of the air of the sewers driven or forced out by the rain water.

It is, however, principally through the house connections that the ordinary ventilation of the sewer should be secured.

A pipe provided to carry down the rain water should not, in our opinion, be provided with a siphon unless it opens below a window in the roof; and one precaution which should be taken, if the arrangement of the roof is such that solid bodies may be washed down, is to provide the top of the pipe with a grating to prevent them from being washed down into the sewers. This pipe, however, while it would ordinarily serve as a ventilating pipe, would not answer the purpose in rainy weather.

The escape pipe for the waste water, if it is carried up through the roof, will serve as a ventilator if it is not closed at its lower end by a siphon. Theoretically it is enough if the siphon is connected with each point of escape in the house—sinks, water-closets, etc.—which leaves to the main pipe its functions as a ventilator; practically, in the interest of both the house and the sewer, it is much better to place at the base of the waste pipe a siphon as an additional precaution to prevent solid bodies from being carried into the sewer, and in this case there should be immediately back of the siphon a special pipe intended for ventilation only.

It is a very good plan, wherever it is possible, and especially in the case of factories and workshops, to carry a pipe from the sewer to the base of the chimney of a steam boiler.

At Frankfort-on-the-Main the engineers considered it necessary to build at high points ventilating towers 35 meters in height.

But considering that in summer, when every one is complaining of bad smells, the air of the sewers, being cooler than that outside, will escape only by diffusion, we believe that it is better to depend for good ventilation on a large number of points of contact between the two atmospheres, obtained by depending upon the house pipes. It is not without interest, before quitting this subject, to remark that by increasing the diameter of sewers we increase the quantity of vitiated air, and, in consequence, from this point of view also, large sewers have anything but an advantage.

The preceding considerations leave us little to say on the question of house connections, and engineers cannot do better than to refer for models to the very excellent dispositions now made by the municipal sanitary service in Paris, in all works made under its direction. In replacing the large pipes formerly used by smaller pipes there is an improvement both in the freer escape of water and in the reduction of the first cost. The precaution of aerating the siphons so that they shall not be washed out by the fall of water from the upper part of the same pipe is important. In low places where, in case of heavy rains, backing up of the water in the sewers is to be feared, we can use very well a sort of valve opening from the house outward toward the sewer; this works very well in Berlin, where it is very generally used.

(TO BE CONTINUED.)

An English Branch Railroad.

As an example of English construction we take from the London *Engineer* the following description of a short branch line lately built by the Midland Company in Yorkshire, which is intended chiefly for local business, although it also completes a loop line from Leeds to Skipton.

Though barely 12 miles long, the Skipton & Ilkley line, as we shall see farther on, has necessitated the construction of a great variety of interesting engineering works. The extremities of the line are practically at the same altitude—viz., 320 ft. above sea-level, but Skipton being in Aire Dale, while Ilkley is in the valley of the Wharfe, the intervening ridge, some 200 ft. higher, has to be crossed. The gradients of the line, therefore, are not particularly good. From Skipton to the summit, nearly four miles, we climb gradients varying from 1 in 90 to 1 in 240, while from the summit down again to Ilkley the ruling gradient is 1 in 100.

The line certainly has no claim to being called a light railway. On its 12 miles will be found one tunnel, three viaducts, 19 public roads, or canal bridges, 45 occupation bridges, some heavy work in the way of retaining walls and culverts, and nearly a million and a half cubic yards of cutting. The line is well laid out, and in designing the works, due regard has evidently been paid to economy. On the other hand, there is nothing to be seen of the cheap-and-nasty style. The work has been well done, the masonry being particularly good. Here and there on the slopes symptoms of slips can be seen, especially in the bad, peaty ground near Embsay; but they were taken in time and properly supported and drained, with the result that no slip of any consequence is now to be found on the whole line.

The accompanying illustration shows the Lob Ghyll viaduct which is in the Wharfe Valley, where the line runs along the hill-side. Lob Ghyll is a deep gorge in the hill-side, which has been cut through the Yoredale shales by the action of the stream; the line is carried over this ravine, which is one of the most beautiful spots in the neighborhood, by a masonry viaduct of five spans 70 ft. high. The arches are segmental, 30 ft. span, with a rise of 12 ft.; the piers are 4 ft. thick at top under the impost, with a batter of 1 in 26 at the ends, and 1 in 40 on the sides. The masonry is snecked rubble of sandstone from the Horsforth quarries, and is a good specimen of its class; the whole of the stonework is rock-faced, the impost, cornice, coping, etc., having a simple chisel draft round the angles and arrises; the viaduct thus harmonizes, as much as any modern structure can, with the lovely scenery surrounding it.

Chrome Pig Iron and Steel.

(Abstract of paper by M. Brustlein, Unieux, France.)

ALLOYS of iron and chromium, containing generally more or less carbon, have been known for a long time as products of the laboratory, but I believe that to the United States is due the first introduction of chrome steel for industrial purposes; at any rate, when, in 1875, I had commenced my experiments in France with the manufacture of chrome iron and steel, I had read that in the United States chrome steel of considerable strength had already been manufactured.

After a series of experiments, which were carried out at the works of Unieux, we commenced, in 1877, to supply chrome steel regularly to our clients; and since that date the use of chromium has become more and more extended at our works. As soon as several other French works became aware of the results we had obtained, they began to imitate us. I believe, however, that we were the first in Europe to show what could be attained with chrome steel. At Unieux, we produced, in crucibles, all the ferro-chrome that was necessary for the steel that we manufactured; but to-day there are several French works that produce chrome iron in the blast-furnace, although we believe that up to the present time the highest percentage of chromium contained in chrome iron made in the blast-furnace has been 49 per cent.

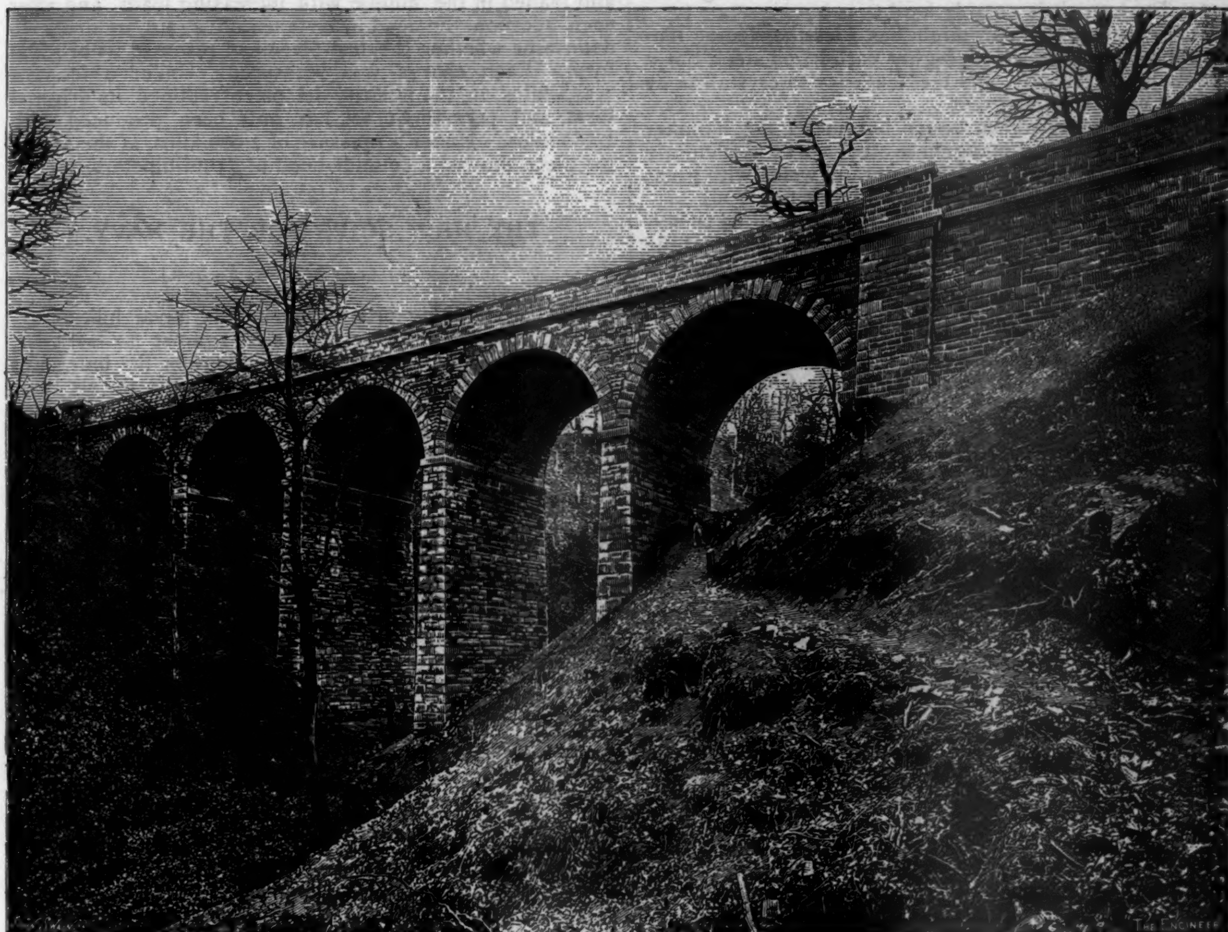
From observation and analysis of a number of specimens submitted, it will be observed that chromium and ferro-chromes possess the property of combining with large percentages of carbon, and that their general appearance varies more according to their percentages of carbon than according to their percentages of chromium. Both chromium and ferro-chrome appear to be able to combine with larger proportions of carbon than either manganese or ferro-manganese can do. On the other hand, however, the ferro-chromes, whether highly carburized or not, do

not appear to crystallize in plates or in large facets like spiegeleisen, and when they show a crystalline fracture it assumes the form of needles or very small facets. This distinguishing difference between chromium and manganese is probably not without some influence on the action which either of these metals exercises in steel. In ferro-manganese, when the percentage of manganese reaches about 30, the iron combined with it loses its magnetic properties. It differs in that respect from ferro-chrome. The iron which the latter contains retains the property of being attracted by the magnet, even in ferro-chromes containing as much as 65 per cent. of chromium. I am of opinion that iron containing chromium can be used with advantage in founding such a metal as may be required to possess hardness and a high capacity of resistance, such as rolls for rolling-mills, etc.; but in such a case it would be necessary to limit the percentage of carbon, as chrome iron with a high percentage of carbon appears to be always brittle.

Chromium appears to have little tendency to combine with copper, with a view to the production of bronze. In a specimen showing the results of an experiment made in order to obtain a chromium bronze, the fracture of the bar indicates a great absence of homogeneity in the metal obtained.

The ordinary ferro-chrome contains usually from 48 to 53 per cent. of chromium, and from 7 to 8 per cent. of carbon. With this composition, ferro-chrome combines with variable proportions of silicon, often exceeding 2 per cent.

Specimens of silico-chrome contain 47 per cent. of chromium, 7 per cent. of carbon, and 5.4 per cent. of silicon.



LOB GHYLL VIADUCT, YORKSHIRE, ENGLAND.

CHROME STEEL.

In the manufacture of steel, one can make use of very variable proportions of chromium. Thus, for example, we have ascertained that a metal containing 2 per cent. of carbon and 12 per cent. of chromium may be forged, and may be classified under the head of steel.

The presence of chromium in steel increases its resistance or tenacity. Thus, in two varieties of steel having the same percentage of carbon, and differing only from each other in so far as the first contains chromium and the second none, the first will have, besides, a notably higher tenacity, as well as a considerably higher resistance of pressure. Steel containing chromium, and properly annealed, will always be a little harder to work in the lathe or on the surface, and the difference in this respect will be increased according as the percentage of chromium is raised. This property renders chrome steel less suited to the manufacture of articles that require a complicated mechanical finish, such, for example, as milling tools.

Chrome steel contains usually from 1.5 to 2 per cent. of carbon, as noted above.

If the two varieties of steel have been suitably manufactured and treated, they will be found equally well adapted to the process of tempering. In chrome steel, however, the temper penetrates to a greater depth. This fact I attribute to the great affinity of chromium for carbon favoring the dissolution of the latter in the metal, and thus maintaining it with greater readiness in the dissolved state.

Before being tempered, the grain of chrome steel differs very little from that of other steel with the same propor-

tion of carbon. In both cases, the fineness of the grain depends mainly on the content of carbon, but on being fractured the first-named is always rather more fibrous.

As a result of being tempered, the grain of chrome steel becomes much finer, and if the percentages of carbon and of chromium are a little raised, the fracture, after tempering, becomes almost vitreous, as in the case of steel containing a high percentage of tungsten.

Chrome steel scales with much greater difficulty in tempering than ordinary steel, so that if we are to judge of the degree of reheating by its appearance, it is necessary to rub the tempered part, so as to remove the adherent film.

If chrome steel is too much heated in the process of tempering, the grain becomes more and more marked; and when it is altogether burnt, the fracture becomes quite crystalline, and the grains, brilliant in appearance, do not readily adhere to each other.

Under the hammer, chrome steel behaves quite as well as ordinary carbon steel. In the process of being cold drawn, however, it is notably harder.

Speaking generally, chromium has a less hardening tendency than manganese on highly carburized steel, but it imparts more tenacity, and the tendency to crystallize by excess of heat is not so great.

Manganese steel works better hot under the hammer than chrome steel, but manganese steel works particularly well. Again, manganese steel generally welds with great facility, while chrome steel welds badly, or not at all.

It has been thought that ferro-chrome could be substituted for ferro-manganese as an addition at the end of the Bessemer or the open-hearth process, but it is certain that the two would not act in the same manner. Ferro-chrome may be readily used as a recarburizing agent, but its oxide does not form a fusible combination; while manganous oxide forms with the silica a readily fusible silicate, which shows itself at the surface of the bath. Chromium, on the other hand, forms an oxide, which is infusible at the temperature of steel, and which does not combine to form a fusible slag. With steel in a state of fusion, there is a tendency to burn in contact with the air. It appears to combine with the oxide of iron. The carbon of the steel is more or less burnt in the immediate neighborhood of the part oxidized, and retains with itself in the still liquid steel the impurities produced. This causes deep veins to appear in the ingots, which no forging at a sweating heat can cause to disappear. This is one of the difficulties that are presented in the treatment of chrome steel. That difficulty is more or less increased according as the steel produced is more or less soft, and as its content of chromium is higher or lower.

The great facility with which chromium oxidizes at high temperature is again shown during the ulterior working of chrome steel. In the reheating furnace, this steel takes a layer of oxide, which is both stronger and less easily got rid of than in ordinary steel. It is this characteristic that renders it difficult, if not impossible, to weld two pieces of steel which contain a notable proportion of chromium.

Having regard to the properties already described, it is easy to understand that it will be equally impossible to obtain a product of a satisfactory character by the puddling of chrome pig iron. The pieces of metal which ought to form the ball take up a layer of infusible and more or less closely adherent oxide, which is not got rid of in the process of shingling, and which prevents the pieces of metal from welding.

For these reasons, I have never attempted the puddling of this description of metal, and I am convinced that if the puddling of a variety of iron containing a notable proportion of chromium were attempted it would fail.

The use of chromium in steel does not exclude the simultaneous employment of a certain proportion of manganese, of silicon, or of tungsten. Thus in practical working many kinds of combinations may be provided for.

I will conclude by giving the details of some experiments which have been made with test-pieces in the presence of the representatives of the principal French railroad companies with a chrome steel having about 0.7 per cent. of carbon. In this experiment we used a bar of 90 × 11.9 millimeters. From this bar we cut an end piece, which was annealed, and from that end piece we cut three test-pieces, No. 1, No. 2, and No. 3. These were turned to 9 mm. diameter, and a length of 75 mm. between the shoulders. Tensile tests gave the following results:

	No. 1. Annealed.	No. 2. Annealed.	No. 3. Tempered in Oil and Annealed Dark Red.
	Kilos.	Kilos.	Kilos.
Elastic limit per square millimeter.......	40.2	43.3	140
Ultimate tensile strength per square millimeter..........	73.0	70.8	150
Elongation per cent. per square millimeter	17.9	21.2	6.2
Relation of the ruptured to the original section..........	0.308	0.333	0.708

From the same bar we cut a piece one meter long, which we bent hot to a head of 100 mm., tempered and annealed. This piece was placed on a weighing-machine, and loaded in the middle with increasing loads, and after each addition the load was taken off again, in order to determine whether the test-piece had resumed its original form. Each charge was measured. Under a load of 1,540 kilos. in the middle, the piece retained its original form, and permanent set has only been produced with 1,580 kilos. Under a pressure of 2,000 kilos. at the center the piece showed a counter-bend of 53 millimeters.

THE NEW SHIPS FOR THE NAVY.

(From the *Army and Navy Register*.)

THE shipbuilding programme in the naval bill, as reported, provides for four vessels as against six last year, but the amount of displacement tonnage in the four ships of this bill is 19,000 as against 23,000 tons in the six ships of 1887. The estimated cost of the four is to be $7,700,000, as against $8,768,000 for the six ships. It will be noticed that the average cost of last year's ships was about $370 per ton of displacement, while in this year's vessels an average of $400 per ton is allowed.

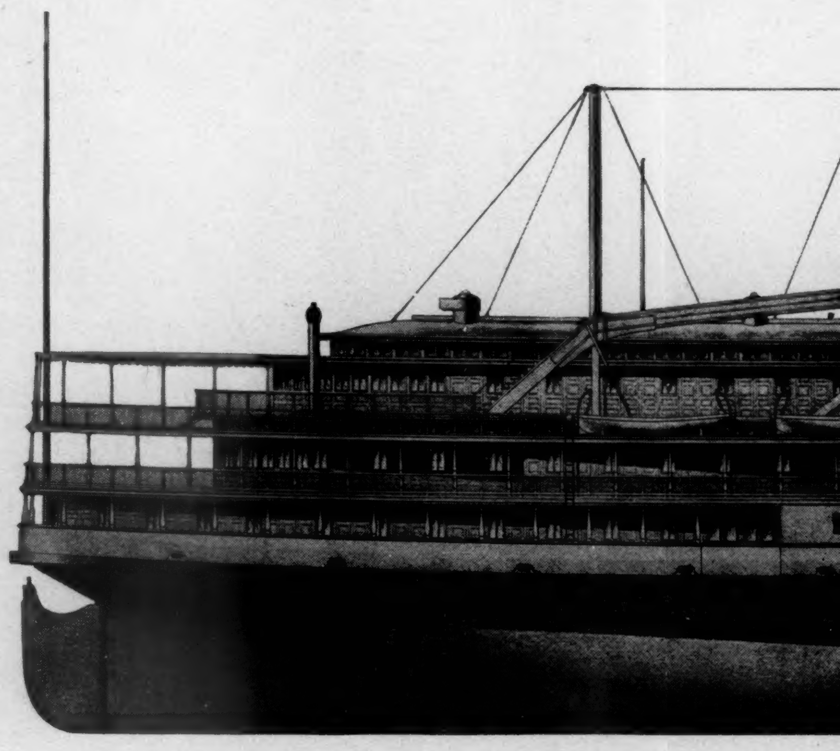
This is because the ships now provided for are to be more heavily engined than their predecessors were, so far as the unarmored vessels are concerned, while the single ironclad provided for in this bill will be almost as powerful as both of last year's armored ships combined. Some allowance has also been made by the committee for probable enhancement of the cost of material caused by elevation of the standard of tests in some particulars, which Secretary Whitney has in contemplation. It may also be said that there is a disposition among members of the House to increase this programme by adding another 3,000-ton ship, making three instead of two, as reported in the bill. This would bring the bill nearly up to that of last year in amount of tonnage, and slightly ahead of it in expenditure.

The ironclad provided for is to be of 7,500 tons displacement, and the Secretary hopes to get a guarantee of 17½ to 18 knots speed for her, in case she should be built by contract. It is well known here that tentative general designs for her construction have been provided by the Secretary, with the advice and assistance of one of the most eminent naval architects of the age, and these designs are pronounced by experts, who have had opportunity to examine them, to constitute the most advanced type of armored seagoing battle ships.

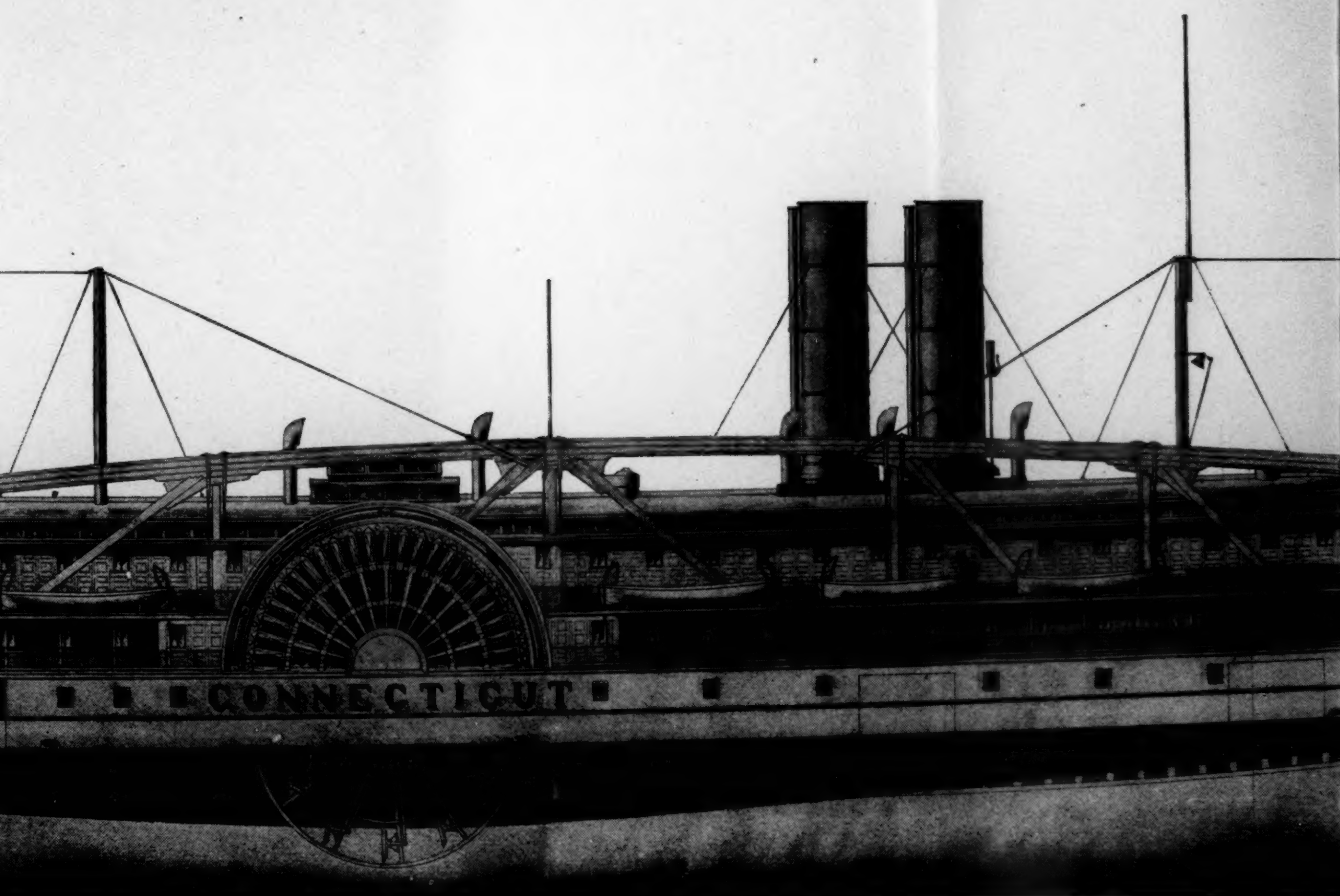
The large unarmored ship described in the bill as of "about 5,300 tons displacement" is intended to be to a great extent a duplicate of the famous *Reina Regente*, lately delivered to the Spanish Government by Thomson & Co., on the Clyde, and which is the fastest as well as most powerful armed cruiser now afloat. The speed developed by the *Reina Regente* on her official trial was 20.8 knots per hour in a two hours' run. And on her first run out to sea she logged over 19 knots an hour for several hours consecutively, which, it is needless to say, has never been equalled by any other vessel of any description. The law requires a guarantee of at least 20 knots for her American counterpart.

STEAMER "CONNECTICUT."

[illegible] TON STEAMSHIP COMPANY

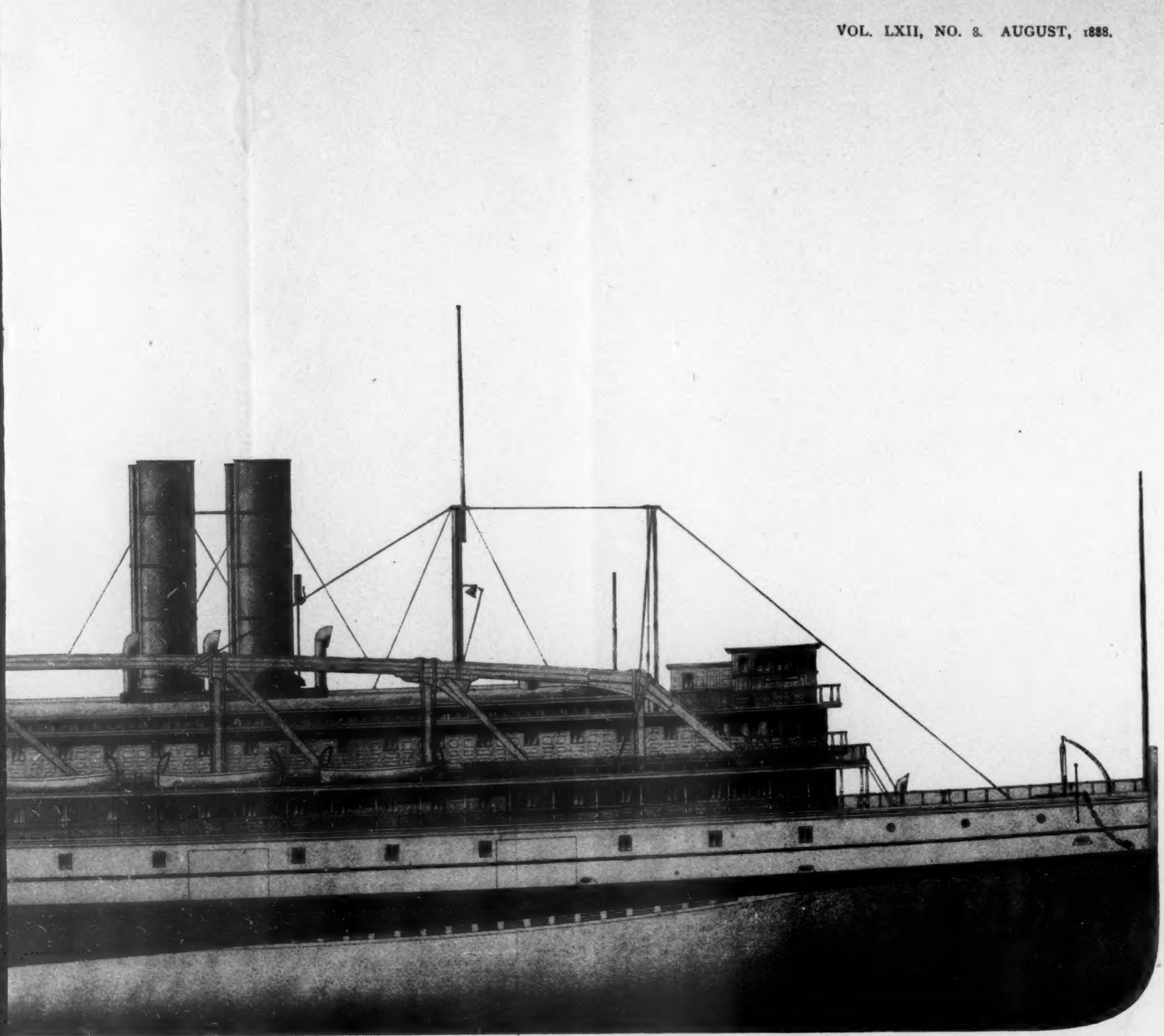


DESIGNE



STEAMER "CONNECTICUT."

SIGNED BY GEORGE B. MALLORY FOR THE PROVIDENCE & STONINGTON STEAMSHIP COMPANY.



Wm. Verhas, del.

NNECTICUT."

OVIDENCE & STONINGTON STEAMSHIP COMPANY.

M. N. Forney.)

No special design has been determined on for the 3,000-ton ships provided for. They may be built on departmental plans or on plans offered by shipbuilders in connection with special bids, as was done last year. They will necessarily be of about the same general dimensions as the *Boston* and *Atlanta*, but of quite different metal, while their H.P. will be at least two and a half times greater than the power of those vessels. They will not carry as heavy guns as are mounted on the *Boston* and *Atlanta*, but their secondary batteries of rapid firing and machine guns will be much more powerful and effective. The law requires these ships to make 19 knots trial speed. It is generally agreed by naval officers that this 3,000-ton class is to be the most useful for general purposes, and will, when fully developed, form the bulk of our cruising fleet. Practically they will occupy a rank in the new navy corresponding to that held in the old fleet by the *Hartford* and *Brooklyn* class of vessels.

It is expected that efforts will be made to secure some modification of the existing law with reference to the physical qualities of the material to be used in construction. The present law requires a minimum of 60,000 pounds tensile strength, with 25 per cent. of elongation in all steel used for the frames and plating of hulls. This require-
quently compelled the rejection of the very best quality of
ment has hampered the Department somewhat, and has fre-
steel, on account of falling a few pounds short of 60,000 in tensile strength, notwithstanding that it exceeded 30 per cent. in elongation and was in every respect admirable hull material. For these reasons a proposition will be made to alter this clause of the law so as to make it read "steel of domestic manufacture and of the best attainable quality," leaving the details to the experts of the department.

"There need be no apprehension," says Captain Phythian, lately Chief Steel Inspector, "that the standard will be lowered. The tendency is constant in the other direction. But the law, as it stands, leaves an inspecting officer absolutely no margin for discretion, and precludes the exercise of mechanical judgment as to the real value of a heat of steel the moment its test pieces show the least deviation of tensile strength below 60,000 pounds."

It may be remarked here that another evil of which manufacturers and contractors complain is the frequent changes of inspecting officers at the steel mills and shipyards. There have been three chief steel inspectors within a year and also three changes of superintending constructor at Cramp's yard during the same period, with still another in prospect. Speaking of this, the engineer of Cramp & Sons resident here says that the effect of these frequent changes is to turn the mills and shipyards into schools of instruction for naval officers in metallurgy and modern shipbuilding, and that while this might be advantageous if they were left long enough in one place to enable them to complete the course, the practice thus far has been to detach officers from inspection duty just when their experience began to be valuable. Much inconvenience, and, in some instances, actual delay, has resulted from this cause.

It is understood that Secretary Whitney desired the committee to provide for two training ships and two or four light draft cruisers for special service on the Chinese coast and rivers, to replace the old *Monocacy*, *Palos*, etc., but they were not incorporated. For some reason not yet explained it is expected that they will be added to the bill in the Senate through an amendment.

Work on the new cruiser *Baltimore* at the Cramp Yard, Philadelphia, has advanced so far that the ship will soon be ready. The gunboat *Petrel* was to be ready for launching about August 1; the *Baltimore* will be ready soon afterward, everything being in good order.

The *Charleston*, built by the Union Iron Works in San Francisco, was launched July 18, and work upon her will be pushed as quickly as possible.

The Pittsburgh Steel Casting Company has the contract for making the stem and stern-posts and other heavy castings for the armored cruiser *Maine*. The stem-post will weigh about 17 tons, and is to be cast in one piece.

THE STEAMER CONNECTICUT.

FOR a number of years past the boats running upon Long Island Sound have disputed with those on the Hudson the claim to be called the finest and most convenient passenger boats in the world. Additions have been made to the fleets owned by the different companies until such vessels as the *Bristol*, the *Rhode Island*, and the *Pilgrim* have become known all over the country. The latest addition to the Sound fleet is the steamer *Connecticut*, which has been built for the Providence & Stonington Steamship Company from the designs of Mr. George B. Mallory, of New York, and which is now nearly ready to take her place on the line between New York and Providence.

The *Connecticut* differs from her chief rival, the *Pilgrim*, in having a wooden instead of an iron hull; she differs also almost entirely in arrangement and details from most other steamers on the Sound. The design of her hull shows a bow line 171 ft. long, or nearly half her length, then a short parallel body, and then stern lines sharper than those usually seen in other boats of this class. Under this plan the center of displacement is thrown much further forward than usual, and, indeed, so far that all freight may be stowed forward of the main deck saloon and none will be carried aft of that point.

The principal dimensions are as follows: Length over all 358 ft. 6 in.

Length on 11-ft. load line, 345 ft.
Beam outside of hull planking 48 ft. 2 in.
Extreme width over guards, 87 ft.
Depth of hold, 17 ft. 3 in.
Extreme depth forward, 23 ft. 6 in.
Extreme depth aft, 20 ft.
Extreme height from bottom of keel to top of pilot house, about 61 ft.

The accompanying illustration, which is taken from the original drawing prepared by the designer, is a very excellent view of the vessel as a whole, and shows her general plan of construction with the outside arrangement of the different decks.

The hull of the *Connecticut* was built by Robert Palmer & Son in their yard at Noank, Conn., and is made in the most solid manner. The frames are of white oak and hackmatack; the keelsons and ceiling of yellow pine; bottom planking of white oak; the wales of yellow pine; main deck and beams of white pine. The floor timbers are filled in solid for 180 ft. of the length of the vessel. The hull is divided by five water-tight bulkheads, extending up to the main deck and entirely across the ship, without openings of any kind. The keel bolts are $\frac{7}{8}$ in. in diameter, of yellow metal, and clinched at the ends on composition plates flush with the surface of the keel. The stern-post is a white oak knee sided and molded 14 in., and fastened by 1-in. yellow metal bolt and clinch-rings.

In the lower hold, under the orlop deck, the first compartment forward of the collision bulkhead is fitted for chain lockers and dunnage rooms. Aft of these are store-rooms, water-tanks and other compartments in which are placed the machinery for working the electric lights. Under the main deck forward is the forecastle, in which accommodations are provided for the crew and the firemen. Aft of the collision bulkhead are the galleys and the pantry for the officers; then comes the lower cabin; then the space occupied by the boilers and the engines. Aft of the engine-room is the galley and pantry for passengers, then the main dining room. Aft of the after water-tight bulkhead the space is occupied by the "glory hole," in which are the rooms for the waiters.

Like the general plan of the boat, the arrangement of the upper decks and joiner work differs considerably from any boats now in use on the Sound. There is accommodation for passengers in the forward and after holds, where there is berthing capacity for about 200 persons. The main portion of the boat used for passenger accommodations is finished in a very substantial and elegant manner, but at the same time in excellent taste, without the profusion of superfluous ornament which is very often seen. The main passenger entrances or quarter deck is finished entirely in solid mahogany. The space aft of the main entrance, which is usually occupied by state rooms, is in this

boat taken up by a café, finished in the same style. This is intended to take the place of the bar-room usually placed forward, and will be conducted as a lunch-room and café, similar to those found in the best hotels.

At the stern, in the usual place, is the ladies' cabin. The ticket-office, coat-room, barber-shop, pantry, and store-rooms are found adjoining. From the after end of the café a stairway leads to the main dining room in the alter hold.

The main saloon on the upper deck is reached by a stairway 15 ft. in width, rising from the forward side of the quarter deck. This saloon is 280 ft. long with a height of about 25 ft. from the floor to the top of the dome or roof. State-rooms are in two tiers ; access to the second tier is given by a gallery running entirely around the saloon. The gallery rails and staircase are of polished mahogany. The state-rooms, of which there are 190 in all, are very handsomely finished and fitted up and are of varying size. They provide accommodations for 600 passengers.

The engine-room enclosure in the saloon is fitted with large plate-glass windows, and the whole interior of the engine-room is finished in polished sycamore, presenting a very handsome appearance. The cabins and the saloons are thoroughly ventilated, air being exhausted by machine fans located in the fire-rooms, and also through ventilating shafts from the main funnels.

Nearly all the cabin and joiner work was done by William Rowland, of New York. The painting, upholstering, furniture, and the electric-light fixtures in the saloon, together with the mahogany work of the main deck, were furnished by Herter Brothers.

The entire boat is lighted by electric lights, two comp'ete dynamos of 800 lamps' capacity being provided, and all the electric fittings are made in conformity with the Navy specification. Electric call-bells and indicators are supplied throughout the boat ; there is also steam-heating apparatus for use when required.

The *Connecticut* differs from most of the steamers on the Sound in her motive power as well as in general design and other arrangements. Mr. Mallory has abandoned the beam engine, which is so universally used; the type adopted is a direct-acting, oscillating, compound engine, with surface condenser.

The engine has a high-pressure cylinder 56½ in. diameter and low-pressure cylinder 104 in. diameter, both being 11 ft. stroke, and both coupled directly to the main shaft. This shaft carries feathering paddle-wheels 28 ft. in diameter, which have 12 buckets 14 ft. wide and 4½ ft. deep. The steam pressure ordinarily carried will be 120 lbs. The steam will be furnished by six gunboat boilers, each 12½ ft. in diameter and 20 ft. 3 in. long. These boilers are placed three together and will be fired from two fire-rooms ; over each is located a centrifugal fan 6 ft. diameter and 5 ft. face, supplying 30,000 cubic feet of air per minute.

The engines are expected to make about 25 revolutions per minute and to develop 4,500 to 5,000 H.P. ; the expected speed which the boat can attain is 17 knots per hour. These engines are the largest oscillating engines ever built.

The total weight of the engines and boilers, including the water in the boilers, will be about 1,000 tons. The surface condenser has about 12,000 square feet of tube surface. There are two air pumps, four feed pumps, and two bilge pumps. All the auxiliary engines work in connection with a separate surface condenser entirely independent of the main condenser. The engine and machinery were built by the William Cramp & Sons Ship & Engine Building Company, Philadelphia.

The direct-acting engine takes much less room than the beam engine, and also weighs considerably less than a beam engine of the same capacity. It may be noted here that the boilers are entirely of steel, and that all the shell rivets were driven by hydraulic riveters. There are two smoke-stacks placed fore and aft, each 8 ft. 6 in. outside diameter.

The chains and anchors wil be handled by a steam windlass made by the American Ship Windlass Company. Steam-steering apparatus is also provided, and there are donkey boilers to supply the hoisting and other engines. The boat is fully provided with fire pumps, hose, and other usual precautions against fire.

It would be interesting to make a comparison between this vessel and the first steamer of the same name, which began to run between New York and Providence in 1822. Unfortunately no accurate description of that vessel has been preserved, but we are informed that she began her regular trips in July of that year, having for a few months previously been employed between New Haven and New York. The old *Connecticut* was owned by the Rhode Island & New York Steamboat Company and ran on alternate days with the *Fulton*. She was 150 ft. long, 26 ft. beam, and 200 tons burden. She had what was known as a "square" or "cross-head" engine of an old type, which has now entirely disappeared. Her boilers were of copper, the fuel used being wood, and so much of this had to be carried that there was very little space left for freight. In speed there was almost as much of a contrast as in size. On her first trip to Providence she left New York, June 4, at 4 P.M., touched at Newport and arrived at Providence at 8 A.M. on June 6, having taken 52 hours for the trip and having been actually about 40 hours in motion, as it is said she laid up 8½ hours at Sands' Point and three hours at Fisher's Island, on account of a heavy easterly wind.

The old *Connecticut* did service on the Sound for a number of years, until replaced by a larger vessel, which in its turn gave way to a still larger one, the new *Connecticut* being the latest development of a long series of improvements.

Steam Sanding Apparatus for Locomotives.

THE accompanying engraving, taken from the London *Engineering*, shows the Holt & Gresham steam sanding apparatus for locomotives, which is manufactured by Gresham & Craven, Manchester, England, and has been adopted on several roads in that country. The advantages claimed for this arrangement over the old method of allowing the sand to pass from the sand-box to the track simply by the action of gravity are that the sand can be delivered at a high velocity directly to the point of contact between the wheel and the rail where it is needed ; and also that the amount supplied can be perfectly controlled. It is further claimed that this apparatus is much more economical, as the sand is not liable to fall clear of the rail or to be blown off. The apparatus is constructed as follows :

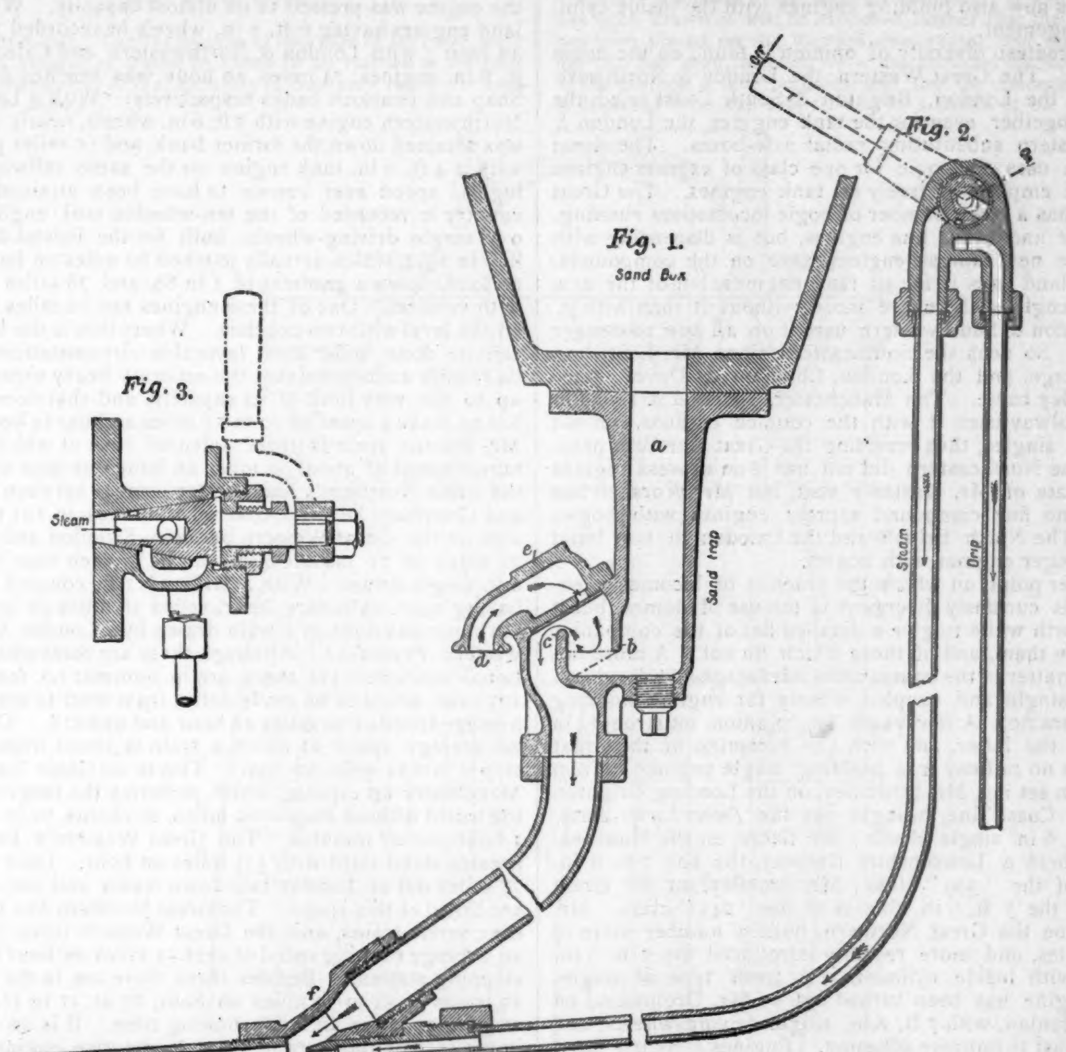
At the bottom of an ordinary sand-box is fitted a sand-trap at *a b*. The sand falls down the pipe *a*, and on reaching *b* passes through the opening shown, and were it not for the vibration of the engine, would take up a sloping position as shown by the inclined dotted line. Owing to this vibration, however, it finally takes the position shown by the horizontal dotted line, at which it remains till steam is turned on through the ejector shown at the bottom of the sand-pipe. When this is done the flow of steam produces a partial vacuum in the sand-pipe, causing air to be drawn in through the air inlet *d*. This air is deflected down on the sand, as shown by the arrows, and carries it with it over the weir *c* down the sand-pipe to the ejector, which blows it on the rail. The hole *g*, shown in front of the ejector nozzle, is to prevent sand accumulating there when steam is shut off, which would otherwise occur. The valve through which steam is admitted to the ejector is of special construction, and forms a very important portion of the apparatus, as it is necessary that any steam leaking past this valve shall not be permitted to reach the sand, and make it damp, as this would interfere with the proper working of the apparatus. To prevent this, a valve of the plug type is made use of, in which the steam is admitted to the center of the plug, passing out by the side opening when the ejector is at work. At all points where leakage may occur grooves are cut to intercept the water, and these are connected with a drip-pipe which discharges into a warm spot below the footplate, so that there is but little chance of the pipe getting blocked by frost.

This apparatus seems capable of doing good service, and would be worth a thorough trial on locomotives. An excellent report of it is made on several English roads.

LOCOMOTIVE PRACTICE.

(From the London *Engineering*.)

"WHY," says the railway passenger when he finds himself seated opposite to an engineer, "why do I see the express locomotives on some lines with outside cylinders, while on other lines they have inside cylinders?" "Why are coupled driving-wheels used by one company and not by another?" "Why have some locomotives domes while some have not?" And so he goes on with his eternal string of questions, to which satisfactory answers are so difficult to find. Of course it is easy to point out that every line has its peculiar features, which are best met by a certain type of engine, and that the present forms have been arrived at by a long course of trial and error. But when every allowance has been made for local peculiarities, there still remains an amount of dissimilarity which is not satisfactorily explained. If the railways were undertaken by the State, and one of the present well-known locomotive superintendents had all the engines placed under his charge, it is certain that, apart from any question of economy of construction and repair, many of the leading types of locomotives would disappear. He would mentally dismiss them at once as coming short of his conception of the best practice, and as opportunity occurred he would break up or remodel them. We have only to assume the post to be given to any one of our leading locomotive engineers to be able to predict which of the many existing patterns of engines would survive or which would be shelved. The personal element would turn the scale, even as one has to confess to the inquisitive passenger it does now. What a great influence it exerts has recently been brought out very clearly by a report addressed by Mr. C. Rous Marten to the Minister of Public Works in New Zealand. Mr. Marten spent many months studying our railways, visiting all those of any importance, and making repeated trips on the most important trains, often on the footplate of the locomotive. He met the managers and engineers of most of our principal lines, and gathered up information of all kinds in a way which shows how great an interest he took in the subject. The locomotive had a special attraction for him, and in a few pages he sketched the principal types in use for heavy express traffic, pointing out how wide are the differences of practice on lines which are not greatly dissimilar in character. Most of the engines to which he alludes have already been illustrated in our columns, but as the locomotive has a fascination for many people who lay no claim to a critical knowledge of it, it will probably be of interest if we follow Mr. Marten in his round of inquiry, and note the differences which he found. In the boilers of engines used for working the fast main line trains the heating surface varies from 1,000 square feet to 1,500 square feet, the following being the areas adopted in the chief classes of express engines: Great Western, 1,278;



STEAM SANDING APPARATUS FOR LOCOMOTIVES.

London & Southwestern, 1,216; London, Brighton & South Coast, 1,284 and 1,485; Great Eastern, 1,200; Great Northern, 1,021 and 1,165; London & Northwestern, 1,074 and 1,450; Midland, 1,121 and 1,313; Manchester, Sheffield & Lincolnshire, 1,144; Northeastern, 1,208; and Caledonian, 1,208 square feet. As regards position of cylinders, the tendency of late has been toward the almost exclusive use of inside cylinders, the most notable exception being the London & Southwestern Railway, which uses outside cylinders for all its passenger engines. There is an exceedingly fine and efficient class of outside cylinder express engines on the Great Northern Railway, but Mr. Stirling is now also building engines with the inside cylinder arrangement.

The greatest diversity of opinion is found on the bogie question. The Great Western, the London & Northwestern, and the London, Brighton & South Coast reject the bogie altogether, even for the tank engines, the London & Northwestern substituting radial axle-boxes. The Great Northern uses the bogie for one class of express engines only, but employs it freely on tank engines. The Great Eastern has a large number of bogie locomotives running, both tank and main line engines, but is dispensing with bogies on new express engines, save on the compounds. The Midland uses it for all tank engines, but of the new express engines there are more without it than with it. The London & Southwestern uses it on all new passenger engines. So does the Southeastern since Mr. J. Stirling took charge, and the London, Chatham & Dover, since Mr. Kirtley came. The Manchester, Sheffield & Lincolnshire Railway uses it with the coupled engines, but not with the singles, thus reversing the Great Northern practice. The Northeastern did not use it on express engines at the date of Mr. Marten's visit, but Mr. Worsdell has built some fine compound express engines with bogies since. The North British and the Caledonian now build all passenger engines with bogies.

Another point on which the practice of locomotive engineers is curiously divergent is the use of domes, but it is not worth while to give a detailed list of the companies which use them, and of those which do not. A more important matter is the comparative advantage and disadvantage of single and coupled wheels for engines working express traffic. A few years ago opinion set strongly in favor of the latter, and with the exception of the Great Northern no railway was building single engines. Then a reaction set in; Mr. Stroudley, on the London, Brighton & South Coast line, brought out the *Imberhorne* class, with 6 ft. 6 in. single wheels; Mr. Sacré, on the Manchester, Sheffield & Lincolnshire Railway, the fine 7 ft. 6 in. singles of the "399" class; Mr. Bromley, on the Great Eastern, the 7 ft. 6 in. singles of the "245" class. Mr. Stirling, on the Great Northern, built a number more of 8 ft. singles, and more recently introduced the 7 ft. 6 in. singles with inside cylinders. A fresh type of single-wheel engine has been turned out by Mr. Drummond on the Caledonian, with 7 ft. 2 in. single driving-wheels, and a sand blast to improve adhesion. Engines similarly fitted are being used on the Midland with excellent results.

Many of these differences are very difficult to explain by reference to the peculiarities of the roads or of the traffic. The lines which use single engines are not the freest from heavy gradients, and those which use bogies have not the sharpest curves. The heaviest trains are not drawn by the engines with the greatest heating surface. The personal opinions of the locomotive superintendent, and the fashion of the hour, exercise an immense influence, which is no doubt increased in some cases by want of opportunity for making comparisons. It is seldom that two different classes of engines do exactly the same work, and consequently it is impossible to compare their performances with precision. There are so many allowances to be made for factors which are not identical in the two problems, that the result depends largely upon the judgment of the man making the calculation. It is only when an engine is pressed to its utmost that the effect of special features in its design and proportions really make themselves apparent. Fast light trains could be run as well 30 years ago as to-day, and slow heavy trains were nearly equally well handled. It is the combination of high speed and great weights which is so trying to the locomotive engineer of to-day. When the engine is pressed to the limits of its capacity, every peculiarity of the road is felt, and a design must be got out which will give the best average result over the run. Mr. Marten's footplate experiences show us with what difficulty the present speeds are maintained. He seems to have made very minute inquiries and observations, and he records that on three occasions only, all of a somewhat special character, did he register a speed of 76.28 miles an hour, with light loads, down gradients of 1 in 89 to 1 in 200; once with a Great Western 8 ft. single, once with a Great Northern 8 ft. single, and once with a Midland 7 ft. coupled having 19-in. cylinders. In each case the engine was pressed to its utmost capacity. With Midland engines having 6 ft. 8 in. wheels he recorded 75 miles an hour; with London & Northwestern and Caledonian 6 ft. 6 in. engines, 74 miles an hour was reached down the Shap and Beattock banks respectively. With a London & Northwestern engine with 5 ft. 6 in. wheels, nearly 72 miles was attained down the former bank, and 60 miles per hour with a 4 ft. 6 in. tank engine on the same railway. The highest speed ever known to have been attained in this country is recorded of the ten-wheeled tank engines with 9 ft. single driving-wheels, built for the Bristol & Exeter line in 1852, which actually touched 80 miles an hour, with no load, down a gradient of 1 in 89, and 78 miles an hour with vehicles. One of these engines ran 70 miles an hour on the level with two coaches. Where this is the best that can be done under most favorable circumstances, it will be readily understood that the ordinary heavy express runs up to the very limit of its capacity, and that down hill it has to make a speed of 70 to 75 miles an hour to keep time. Mr. Marten records three splendid runs at which a sustained speed of about 60 miles an hour was kept up; with the Great Northern's Manchester express between London and Grantham he twice covered 100 miles in 103 minutes, and on the Great Western between Swindon and London 72 miles in 71 minutes, the engine in each case being an 8-ft. single driver. With a Midland 7-ft. coupled engine, having 19-in. cylinders, he travelled 58 miles an hour, and the same was done in a train drawn by a London & Northwestern *Precedent*. Although these are somewhat exceptional examples, yet there are in summer no fewer than 105 runs timed to be made daily, from start to stop, at an average speed of 50 miles an hour and upward. The highest average speed at which a train is timed from start to stop is just 54 miles an hour. This is the Great Northern's Manchester up express, which performs the longest run in the world without stop—105 miles, 26 chains, to be done in 1 hour and 27 minutes. The Great Western's Exeter expresses stand third with 53¼ miles an hour. Over the first 77 miles out of London two down trains and one up train are timed at this speed. The Great Northern has no fewer than seven trains, and the Great Western three, timed at an average running speed of over 53 miles an hour between stopping stations. Besides these there are in the country 25 trains at 52 to 53 miles an hour, 27 at 51 to 52, and 40 at 50 to 51 miles an hour running time. It is no wonder, in the face of these speeds, that locomotive engineers are feeling in all directions to get engines of greater power. Mr. Webb is going in bodily for the compound system, and appears to be getting splendid results out of it. Mr. Worsdell is also adopting the compound system—worked out on another way—very freely, while others are waiting to see the results. On our great competing lines we have come to the limits of the capacity of the ordinary locomotive, whatever the form it takes, and if trains are to be increased in weight, or speed to be materially augmented, some new departure must be made.

A Proposed California Bridge.—The Southern Pacific Company is now having surveys made to ascertain whether it will be practicable to build a bridge across the Strait of Carquinez, to take the place of the steam ferry by which trains are now transferred there. In order to avoid, as much as possible, interruption to navigation, it is proposed to make a bridge 100 ft. at least above high-water mark. Its entire length will be between 3,500 and 4,000 ft.; the depth of water varies from 55 to 180 ft., but the bottom is generally rock, so that it is not thought there will be much difficulty in finding foundation for the piers. No decision as to the building of the bridge will be reached until the surveys are completed.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

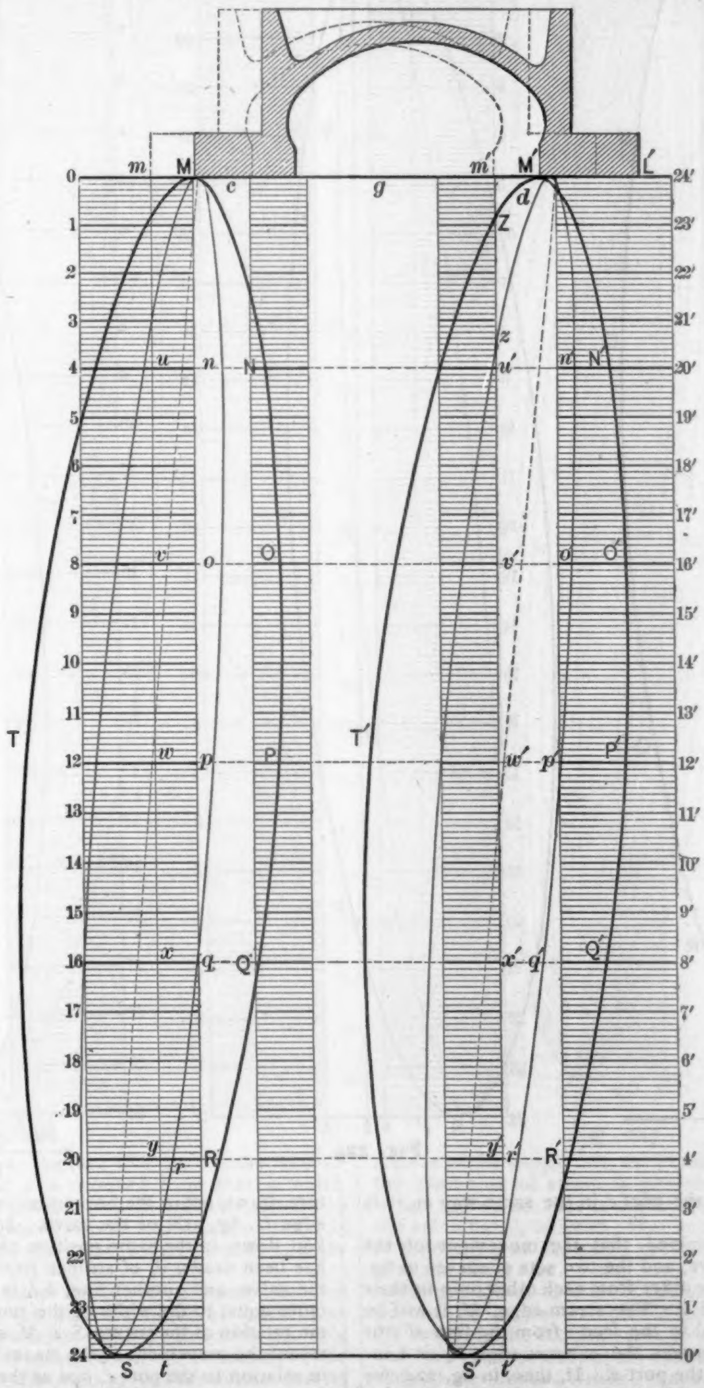
(Continued from page 326.)

CHAPTER XIII.—(*Continued.*)

THE VALVE GEAR.

QUESTION 340. *Can the position of each edge of the valve, with any given amount of travel, be shown in its relation to the ports by one motion-curve, or is it necessary to draw such curves for each edge of the valve?*

bered that the movement of any portion of the valve is exactly the same as that of every other part, and therefore the curve which represents the motion of one part is exactly like that which represents the movement of any other part. This is shown in fig. 218, in which the two sets of curves, below *M* and *M'*, are exactly alike. Therefore, all that is needed to show the movement of any part of the valve in relation to the ports is to draw lines to represent the ports in their relative positions to the valve. In this way one curve can be made to show the movement of all the parts of the valve in relation to the ports below it. To illustrate this, it will be assumed that a motion-curve, *M N O P Q R S T*, fig. 223, which represents the maximum travel of a valve, has been drawn with the instrument described in answer to the previous question. When this curve has been drawn it will be supposed further that the crank-pin has been placed on the forward dead-center, and the shaft *F*, fig. 222, has been fastened by a nut provided for that purpose in the position it then occupies, and that the connecting-rod *H* is detached from the arm *G*, and by a stroke of the piston the



Answer. One motion-curve is sufficient to represent the movement of any part of the valve in relation to the ports during its entire travel. This will be apparent if it is remem-

pencil *P* has drawn a straight line, *M s*, fig. 223. This line will represent the position of any part of the valve when the crank is on the front center, and the curve will represent the movement

and position of the same part during one revolution of the crank-pin. It will be supposed that the line $M\,s$ represents the position of the steam-edge M, fig. 218, of the valve at the beginning of the stroke. Usually, when a valve worked by a link motion has its greatest travel, it has no lead at the beginning of its stroke, but its edge conforms to that of the steam-port, or, as it is expressed, it is set "*line-and-line*" with the port. If that is the case the line $M\,s$, fig. 223, will represent the edge of the steam-port. If the valve has lead, then a line drawn parallel to $M\,s$, at a distance from it equal to the lead, will represent the edge of the port. In fig. 224 the valve is shown with $\frac{1}{16}$ in. lead, and another line, $a\,b$, has been drawn at a distance from $M\,s$ equal to the width of the port c, fig. 218. The curves $M\,N\,O\,P\,Q\,R\,S$ and $M\,n\,o\,p\,q\,r\,S$ then represent the motion to $M\,s$, and assume that M, fig. 224, represents the exhaust-edge of the valve, then the relation of the two curves to the lines $m'\,t'$ and $h\,i$ will represent the motion of the valve in fig. 224 in the same way as it is shown by the curves $M'\,N'\,O'\,P'\,Q'\,R'\,S'$ and $M'\,n'\,o'\,p'\,q'\,r'\,S'$ in fig. 218. Thus the one set of curves will represent the motion of the valve in relation to both of the steam-ports during the backward stroke of the piston. It remains to show its motion during the forward stroke.

It will be understood that if a line, $K\,S'$, fig. 223, is drawn when the crank-pin is on a dead center and the piston at the back end of the stroke, that it will represent the position of the edge of the valve when the piston is in that position or is at the beginning of the forward stroke, just as $M\,s$ represented it at the beginning of the backward stroke. A vertical line, L', is there-

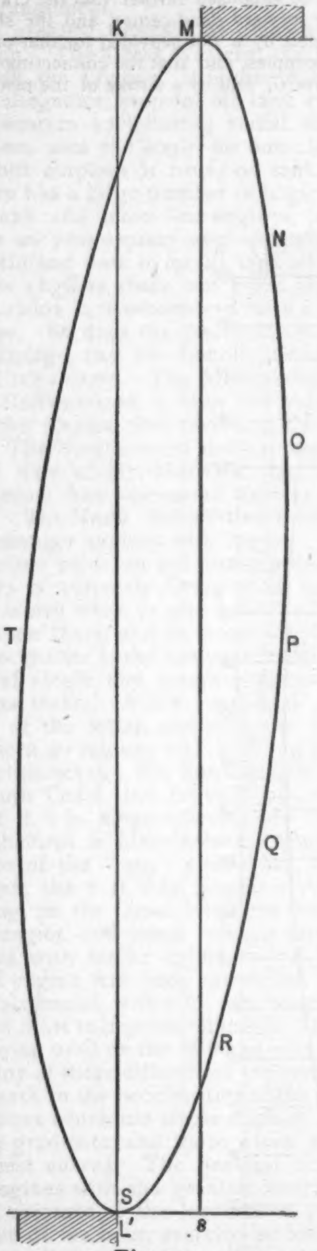


Fig. 223.

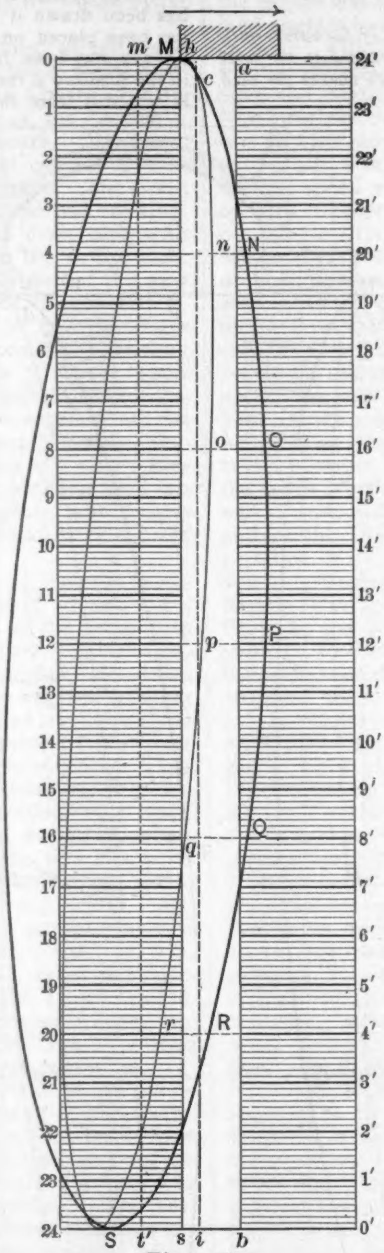


Fig. 224.

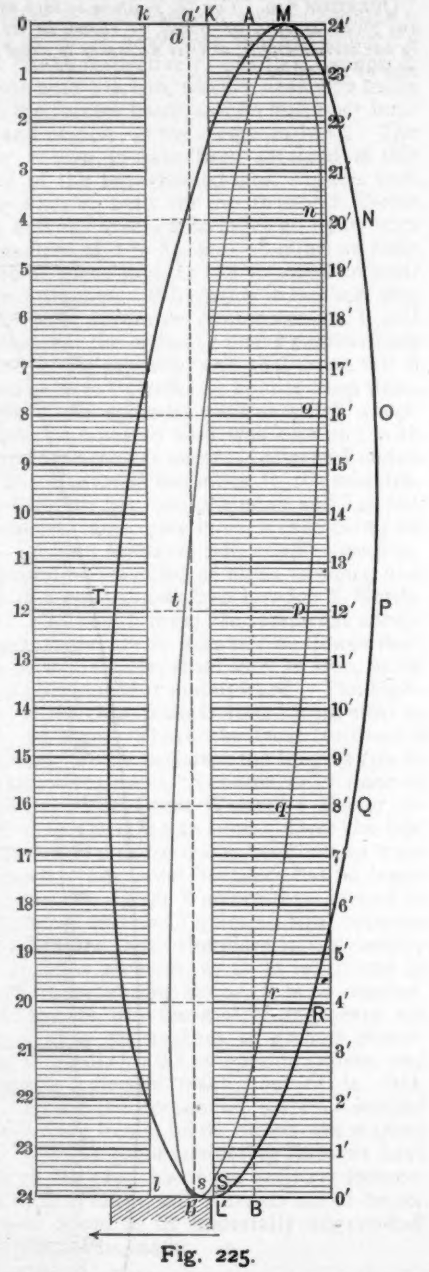


Fig. 225.

of the valve in relation to the port c in the same way as it is shown in fig. 218.

It has already been explained, that the movement of the edges M and M' of the valve, and the two sets of curves in fig. 218, are exactly alike. They differ from each other only in their relation to the ports c and d. The steam-edge, M, it will be seen, is $\frac{1}{16}$ of an inch—equal to the lead—from the line $M\,s$ or the edge of the port c, whereas the exhaust-edge M' is 1 in. from $m'\,t'$, the inner edge of the port d. If, then, in fig. 224, we draw a line $m'\,t'$, 1 in. from M, and another, $h\,i$, at a distance from $m'\,t'$ equal to the width of the port d, fig. 218, and parallel fore drawn below the horizontal line $L'\,s$ to represent the steam-edge L', fig. 218, of the valve. In fig. 225 the line L' has been laid down in the same position as in fig. 223, but the line $K\,L'$ has been drawn $\frac{1}{16}$ of an inch from L', to represent the lead of the valve, and another line, $k\,l$, is drawn parallel to it at a distance equal to the width of the port d, fig. 218. If this is done the relation of the curves $S\,T\,M$, and $s\,t\,M$ in fig. 225, will represent the movement of the steam-edge L', fig. 218, of the valve in relation to the port d, just as the movement of M is shown in fig. 224.

To show the motion of the exhaust-edge L in relation to the

port *c*, fig. 218, a line, *A B*, is drawn in fig. 225 1 in. from *L'*, or in the same relative position to *L'* that *m' t'* occupies to *M'* in fig. 218. Another dotted line, *a' b'*, is drawn in fig. 225 at a distance from *A B* equal to the width of the port *c*. The relation of the curves *S T M* and *s t M* to these dotted lines will show the motion of the exhaust-edge *L* of the valve to the port *c*, fig. 218, just as that of *M'* was shown in fig. 224. It will require no explanation to show that the two diagrams, figs. 224 and 225, can be combined in one, as shown in fig. 226, and in that way the movement of the valve in relation to each of the steam and of the exhaust-port may be shown during a complete revolution of the crank by one set of motion-curves.

then it will be in the same relation to the port indicated by the dotted lines *m' t'* and *h i* that it has to *d* in fig. 218.

Diagrams of this kind, which are made full size, will, of course, show the movement of the valve more distinctly than is possible in the space occupied by the illustrations herewith. When they are made full size, the lines indicating the ports should be drawn of different colors, so as to distinguish them from each other easily. Such diagrams will show the position of the valve in relation to the ports and indicate the distribution of the steam during the whole stroke. It is only necessary to refer the curve to the proper line to determine the position of the valve in relation to either of the ports for either the admission or

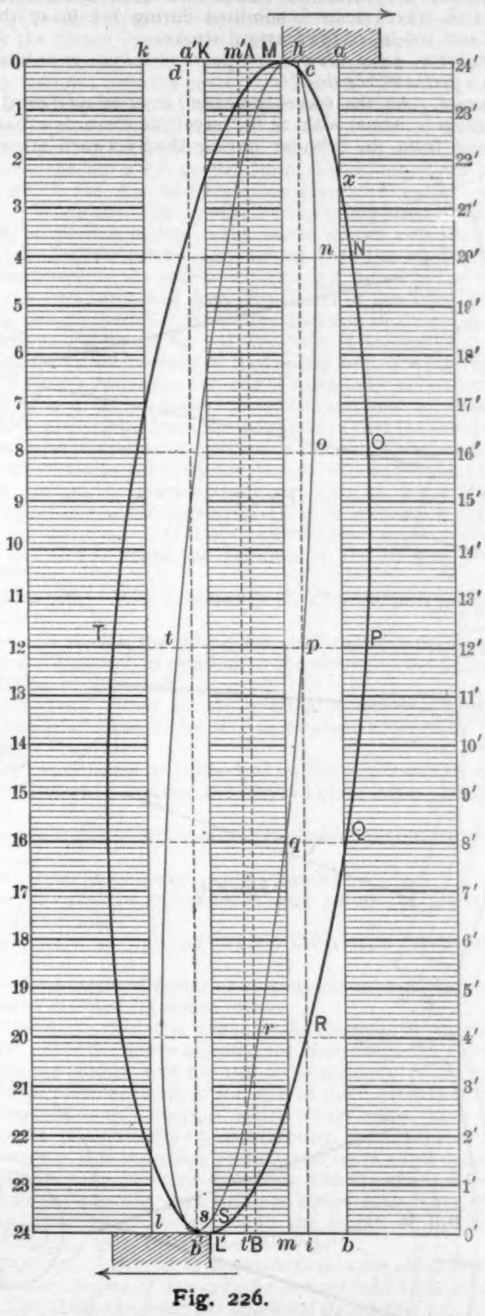


Fig. 226.

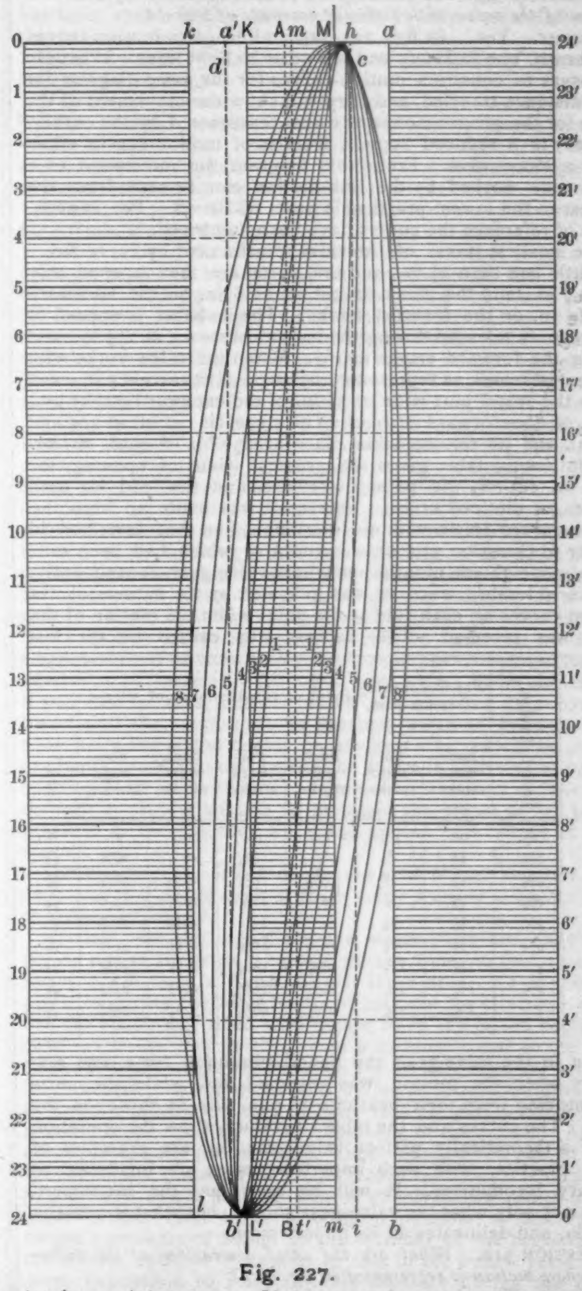


Fig. 227.

It will be seen that in a diagram like fig. 226 the relative position of the ports *c* and *d* is reversed from that in which they actually are, as shown in fig. 218. If desirable, the inner edges of the exhaust-port *g* could also be laid down on the diagram, so that the motion of the valve with reference to them would be shown.

If the reader will cut a paper section of a valve, like that shown in fig. 51, and place the different edges, *a*, *f*, and *b*, so that they will successively correspond with the line *M* in fig. 226, the diagram will, perhaps, be more clear. If, for example, the paper section be placed to the right of the line *M*, so that its edge *a* will correspond with *M*, then it will be seen that the port *c* occupies the same relation to it that it does in fig. 218. If the valve be placed so that the edge *b* corresponds with *M*,

release of the steam. If, for example, we want to observe how the admission of steam is governed by the valve, by referring to fig. 226 we see that at the beginning of the backward stroke the valve has $\frac{1}{16}$ in. lead; that at $2\frac{1}{4}$ in. of the stroke the port *c* is wide open, as shown by the intersection of the motion-curve with the line *a b* at *x*; that the valve has received its maximum backward travel at 9 in. of the stroke, and begins to close the port at $16\frac{1}{2}$ in., and completely closes it at $21\frac{1}{2}$ in. of the stroke. By referring the motion-curve to the lines *K L'* and *k l*, we see that the valve as shown, *L'*, again has $\frac{1}{16}$ in. lead at the beginning of the forward stroke; that the steam-port is wide open at $1\frac{3}{4}$ in. of the stroke; begins to close at $16\frac{3}{4}$ in., and is completely closed at $21\frac{1}{2}$ in. By referring the curve to the lines *m' t'* and *h i*, we see that the front port begins to open to the ex-

haust before the piston has completed its forward stroke, that it is wide open almost immediately after the piston begins its stroke, does not begin to close until the piston has moved 20 in. of its stroke, and is completely closed at $23\frac{1}{8}$ in. of the stroke. By referring the curve to the lines *a' b'* and *A B*, almost the same phenomena will be observed for the forward stroke of the piston. In fact, from such a diagram the whole motion of the valve can be studied and analyzed with the greatest accuracy; and, as has already been shown, the motion imparted to a slide-valve by a link is of so complicated a nature that it is almost or quite impossible to observe its exact nature without diagrams of some kind.

QUESTION 341. *Can a diagram be constructed to represent the motion of the valve with different amounts of travel?*

Answer. Yes. In figs. 224, 225, and 226, two motion-curves are shown, one in heavy and the other in light lines. It is only necessary to construct motion-curves for the same diagram for each distance traveled, and they will show the movement of the valve for the given amount of travel represented by the curves. Fig. 227 is a reduced copy of a series of motion-curves taken from a locomotive. From this diagram the movement of a slide-valve worked by the link-motion can be seen from the highest to the lowest practicable point of cut-off. For convenience of reference the curves have been numbered.

The smallest travel of the valve represented by curve No. 1 is a little less than $2\frac{1}{4}$ in., and the ports are then opened only about $\frac{3}{8}$ in., and the steam is cut off at 8 in. on the backward and $6\frac{1}{2}$ in. on the forward stroke. The exhaust is opened or the steam is released during the backward stroke at $17\frac{1}{4}$ in., and during the forward stroke at $16\frac{5}{8}$. When the valve works with its greatest travel, as represented by curve 8, it travels 5 in., and opens the steam-port wide at $3\frac{1}{2}$ in. of the backward stroke and $2\frac{1}{2}$ in. of the forward stroke. The steam is cut off at $20\frac{5}{8}$ and $20\frac{1}{2}$ in., and its release takes place at $23\frac{1}{8}$ in. of each stroke. The following table gives the greatest width of opening, the point of cut-off, the point of release, and the lead for such a series of motion-curves. This table was made up from the motion-curves drawn with an instrument like that described in answer to Question 339, on a locomotive which had been running about eighteen months and whose valve-gear, consequently, was considerably worn, as was indicated by the flatness of the motion-curves on each side at the point when the motion of the valve was reversed. This flatness was caused by the lost

No. of curve.	Travel of valve.	Width of opening of steam-port.		Point of cut-off.		Point of release.		Lead.
		Backward stroke.	Forward stroke.	Backward stroke.	Forward stroke.	Backward stroke.	Forward stroke.	
	in.	in.	in.	in.	in.	in.	in.	in.
1	$2\frac{1}{4}$	$\frac{11}{32}$	$\frac{5}{16}$	8	$6\frac{3}{4}$	17	$16\frac{5}{8}$	$\frac{9}{32}$
2	$2\frac{5}{8}$	$\frac{7}{16}$	$\frac{13}{32}$	$9\frac{1}{2}$	$9\frac{1}{2}$	$18\frac{5}{8}$	$18\frac{5}{16}$	$\frac{1}{4}$
3	$2\frac{7}{8}$	$\frac{9}{16}$	$\frac{3}{8}$	12	$11\frac{7}{8}$	$19\frac{3}{4}$	$19\frac{9}{16}$	$\frac{7}{32}$
4	$3\frac{1}{8}$	$\frac{11}{16}$	$\frac{21}{32}$	14	14	$20\frac{11}{16}$	$20\frac{9}{16}$	$\frac{3}{16}$
5	$3\frac{1}{2}$	$\frac{7}{8}$	$\frac{27}{32}$	$16\frac{1}{8}$	$16\frac{1}{8}$	$21\frac{11}{16}$	$21\frac{5}{8}$	$\frac{5}{32}$
6	4	$1\frac{1}{8}$	$1\frac{3}{32}$	$18\frac{1}{4}$	$18\frac{1}{8}$	$22\frac{3}{8}$	$22\frac{1}{4}$	$\frac{1}{8}$
7	$4\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$19\frac{5}{8}$	$19\frac{1}{2}$	$22\frac{13}{16}$	$22\frac{3}{4}$	$\frac{3}{32}$
8	5	$1\frac{1}{4}$	$1\frac{1}{4}$	$20\frac{5}{8}$	$20\frac{1}{2}$	$23\frac{1}{8}$	$23\frac{1}{8}$	$\frac{1}{16}$

motion in the valve-gear, the pencil remaining for a time stationary when the motion was reversed and while the parts were moving from their bearings on one side to those on the other. The curves and the table, therefore, show the operation not of a theoretically perfect valve-gear, but are examples of actual practice, with such imperfections as are incidental to ordinary locomotives. It will be seen that the instrument shows not only what the valve-gear should, but what it actually does do, and delineates all its imperfections.

QUESTION 342. *What are the chief dimensions of the valve-gear whose motion is represented in fig. 227?*

Answer. The throw of eccentrics was 5 in., the steam-ports were $1\frac{1}{4}$ in., and the exhaust-port $2\frac{3}{8}$ in. wide, the valve had $\frac{7}{8}$ in. outside and $\frac{1}{16}$ inside lap and $\frac{1}{16}$ in. lead at full stroke.

QUESTION 343. *What relation is there between the distance which the ports are opened by the valve and its travel when worked by a link?*

Answer. As explained in the answer to Question 121, the width which the steam-ports are opened by the valve for the admission of steam diminishes with the travel of the valve. This is shown very clearly by the motion-curves and also in the above table, from both of which it will be seen that when the valve travels only $2\frac{1}{4}$ in. the steam-ports are opened only $\frac{11}{32}$ in. for the back stroke and $\frac{5}{16}$ for the front. With $2\frac{5}{8}$ travel the opening is $\frac{7}{16}$ and $\frac{13}{32}$ in. With 4 in. travel the port is opened $1\frac{1}{8}$ and $1\frac{3}{32}$ in., and with $4\frac{1}{2}$ in. travel they would be opened wide. With $4\frac{1}{2}$ and 5 in. travel, as will be seen from the motion diagram, the ports are not only opened wide, but the valve throws "over" them, or travels beyond their inner edges.

QUESTION 344. *How is the point of cut-off affected by the link?*

Answer. Changing the travel of a valve with a link has a very similar effect to that produced by eccentrics of different throw—that is, the period of admission is increased with the throw of the eccentric and that for expansion lessened. This is shown clearly in both the motion diagram and the table. With the first curve and a travel of $2\frac{1}{4}$ in. the steam is cut off at 8 in. for the backward stroke and $6\frac{3}{4}$ in. for the front, and with 5 in. travel steam is admitted during $20\frac{5}{8}$ in. of the backward and $20\frac{1}{2}$ in. of the forward stroke.

QUESTION 345. *How is the point of release or exhaust of the steam affected by the link?*

Answer. As the travel increases, it is delayed until later in the stroke. Thus, with $2\frac{1}{4}$ in. travel the steam is exhausted or released from the cylinder during the backward stroke when

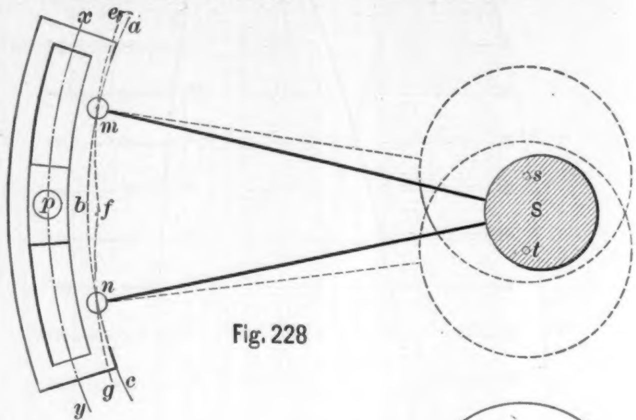


Fig. 228

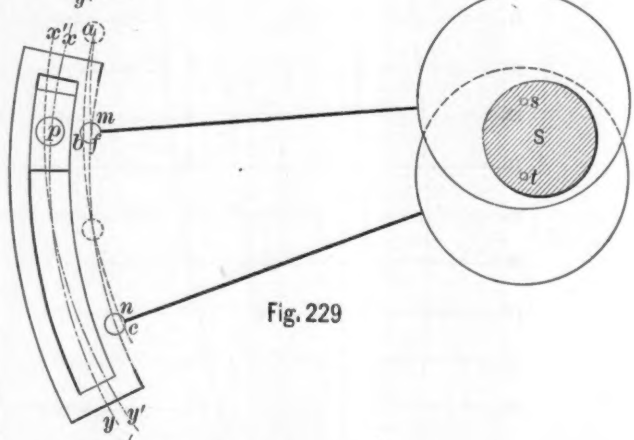


Fig. 229

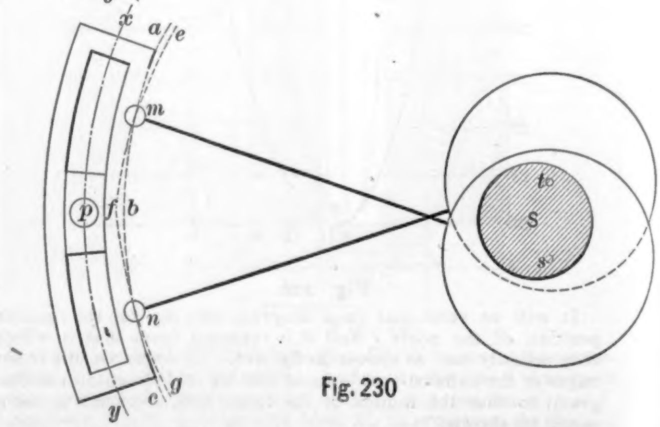


Fig. 230

the piston has moved 17 in., and on the return stroke at $16\frac{5}{8}$ in., whereas, with 5 in. travel of the valve, the release is delayed until $23\frac{1}{8}$ in. of the stroke. An examination of the diagram and table will show very clearly the relation of the point of release to the travel.

QUESTION 346. *How is the lead affected by the ordinary link-motion?*

Answer. It is increased as the travel is diminished, as is

shown in the table, and also by the inclination of the curves at the top and bottom of the diagram.

QUESTION 347. *What is the cause of this change of the amount of lead?*

Answer. This can be best explained by reference to fig. 229, which represents a link with very short eccentric rods. If the center from which the link was drawn was in the center of the axle *S*, and the eccentric straps embraced the axle instead of the eccentrics, their ends *m* and *n*, from *S* as a center, would each describe the same arc, *a b c* parallel with the center line, *x y*, of the link, and the latter could then obviously be raised and lowered without moving the block *b* or rocker-pin *p* at all. But the eccentric straps being attached to the eccentrics, as shown by the dotted lines, when the rods are raised or lowered they describe arcs *e f* and *f g*, from the centers *s* and *t* of the eccentrics, and not from the center of the axle. When the link is lowered, then, the end *m* of the upper rod obviously moves in the arc *m f*, and the top of the link is moved toward the axle, a distance equal to *b f*, as shown in fig. 230, equal to the interval between the arc *a b c*, drawn from the center of the axle, and *e f*, which the rod *m s* describes from the center of its eccentric. When the link is raised from mid-gear, fig. 229, to back-gear, a similar action takes place, as the end *n* of the lower rod then describes an arc, *n f*, so that the whole link is again thrown toward the axle a distance, *b f*, equal to the space between the arcs described from the center of the axle and the centres of the eccentrics. When the position of the eccentrics is reversed, as shown in fig. 231, the link is moved from the axle, thus causing an increase of lead on the opposite side of the valve. We have employed for our illustrations very short eccentric rods, in order to make this action apparent by exaggerating it. It is obvious from the engravings that the difference in the lead is increased as the eccentric rods are shortened, and also as the distance between the points of connection of the rods with the link is increased. It will also be plain that increasing the throw of the eccentrics—that is, increasing the distance of the centers *s*, *t*, of the eccentrics from the center *S* of the axle will also increase the variation in the lead in full and mid-gear.

QUESTION 348. *What is meant by the distribution of steam in the cylinder?*

Answer. It means the admission and exhaust of steam to and from the cylinder in relation to the stroke of the piston or the revolution of the crank.

QUESTION 349. *What are the principal periods or elements of the distribution of steam by the slide-valve and link-motion?*

Answer. They are:

1. The *pre-admission* or lead—that is, the admission of steam into the cylinders in front of the piston before it has completed its stroke.
2. The *admission* of steam after the piston has commenced its stroke.
3. The *expansion* of steam in the cylinder.
4. The *pre-release* or exhaust of steam before the piston has completed its stroke.
5. The *release*, or exhaust during the return stroke of the piston.
6. The *compression* of steam or closing the exhaust before the piston has completed its return stroke.

QUESTION 350. *What is meant by the clearance of the piston?*

Answer. It is the space between the piston and the cylinder-head when the former is at the end of its stroke. If the piston touched the cylinder-head at the end of each stroke, it would cause a concussion or "thump," which would injure these parts. Owing to the impossibility of constructing machinery with absolute accuracy, it is therefore necessary to leave a space, usually from $\frac{1}{4}$ to $\frac{1}{2}$ in. wide, between the piston and the cylinder-heads, so as to be certain that they will not strike each other should there be any slight inaccuracies in the length of the piston-rods, connecting-rods, frames, or other parts.

QUESTION 351. *Why is it desirable to open the steam-port and admit steam at the end of the cylinder toward which the piston is moving BEFORE the latter has completed its stroke?*

Answer. Because it is essential, in order to insure a good action of the steam, that the maximum cylinder pressure should be attained at the very commencement of the stroke. If the steam-port was not opened until after the piston had commenced its stroke, some appreciable time would be consumed in filling the clearance space and the *steam-way* with steam.* It is also found, especially if an engine is working at a high speed, that a slide-valve worked by the ordinary link-motion will not open the steam-port rapidly enough to enable steam of the maximum boiler pressure to fill the space after the receding piston, unless the valve begins to open the port *before* the piston reaches the end of its stroke.

Another advantage resulting from the pre-admission of steam consists in the smooth working of the engine at high speeds, a circumstance which reduces greatly the wear and tear of the working gear. As the piston approaches the end of its stroke, the pre-admitted steam forms a kind of elastic cushion, which is well calculated to absorb the momentum of the reciprocating parts at that instant. The pressure due to the momentum of these parts will, of course, depend upon their weight and the speed of working, increasing directly as the square of the speed. It follows from this that the lead should increase with the speed, and that it should be greatest at high speeds. As has been shown before, this condition is fully accomplished by the ordinary shifting-link motion.

QUESTION 352. *Upon what does the admission of steam into the cylinder depend?*

Answer. It depends in the first place upon the opening of the throttle-valve, and the size of the pipes and passages through which it is conveyed from the boiler to the cylinder. In the second place, it depends upon the time and amount of opening of the steam-port by the valve.

QUESTION 353. *What should be the pressure of the steam in the cylinder during admission?*

Answer. In order that the steam may be used to most advantage, it should be admitted and maintained in the cylinder as near full boiler pressure as possible during the whole period of admission. If the opening of either the throttle-valve or the steam-ports is not sufficient to allow the steam to flow into the cylinder at full boiler pressure, the steam is said to be wire-drawn, and some of the advantage of using it expansively, as has already been explained in answer to Question 92, is then lost.

QUESTION 354. *Why is it difficult to admit and maintain steam at the full boiler pressure in the cylinder during admission?*

Answer. Because it is necessary to reduce the travel of the slide-valve in order to cut off the steam "*short*," or soon after the beginning of the stroke of the piston. When the travel is reduced, the valve opens the port only a small distance, so that the area of the opening is not then sufficient to allow the steam to flow into the cylinder with sufficient rapidity to fill it at full boiler pressure, especially if the engine is working at a high speed. Thus, by referring to the table given on page 368 and to the motion-curves in fig. 227, it will be seen that when the steam is cut off at from $\frac{1}{4}$ to $\frac{1}{3}$ stroke, the port is opened for the admission of steam only from $\frac{1}{8}$ to $\frac{1}{4}$ in. wide. From the curves it will also be seen that the valve then acquires its maximum travel and the steam-port its greatest width of opening very soon after the piston begins its stroke; after which the port is gradually closed, so that before the steam is entirely cut off the opening is so much reduced in area that the steam cannot flow through it rapidly enough to maintain the steam at full boiler pressure in the cylinder when the engine is working at high speeds.

QUESTION 355. *What means are used to overcome this difficulty and thus admit steam at fuller boiler pressure when the valve is cutting off short?*

Answer. In the first place, the steam-ports are made from ten to twelve times as long as they are wide, so that a narrow opening will have a comparatively large area. In the second place, by giving the valve lead, not only are the clearance space and the steam-way filled with steam when the piston begins its stroke, but the port is then open a distance equal to the lead. With the ordinary link-motion, as has already been shown, this lead increases as the travel and period of admission diminish, so that the smaller the total distance that the port is opened, the greater is its opening at the beginning of the stroke. As the steam is usually cut off short when locomotives run at high speeds, it will be seen that the increased lead which is imparted to the valve by the shifting link is an advantage rather than a disadvantage. But while it is often possible in this way to secure a pressure of steam in the cylinder at the beginning of the stroke equal or nearly so to that in the boiler, yet it is almost impossible to maintain this pressure during the whole period of admission, when the steam is cut off short and the engine working at a high speed. To obviate this evil what is called the Allen valve was designed, which is represented in fig. 231. This valve has a channel or supplementary port, *a a*, which passes over the exhaust cavity, and has two openings, *b b'*, in the valve-face. When the valve begins to admit or "*take*" steam at *f*, as shown in fig. 232, it will be seen that it also uncovers the opening *b'* at *e* and thus admits steam at *e'*, which passes through the channel *a a* and enters the steam-port *c* at *b*, and in this way there is a double opening for the admission of steam. The opening *b* of the supplementary port is closed as the valve advances, but when this takes place the steam-port is uncovered far enough at *f* to admit all the steam that is required. This form of valve is very efficient when the travel

* The steam-ways are the passages which lead from the steam-chest to the cylinder, and are sometimes called steam-ports, but the term steam-ways is used to distinguish the passages from their openings in the valve-seat, which latter are more properly called steam-ports.

and point of cut-off are very short. It then gives just twice as much opening as the ordinary valve for the admission of steam.

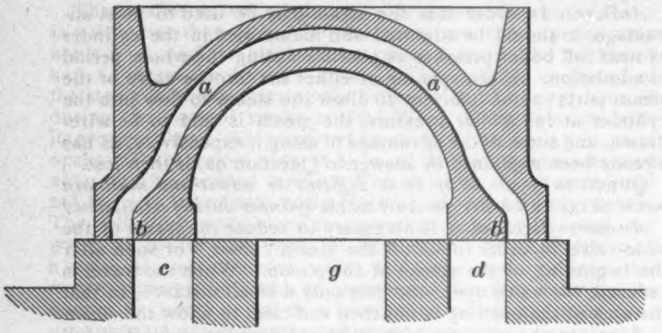
QUESTION 356. *What is meant by the pre-release of steam?*

Answer. It is the release of the steam before the piston has completed its stroke. If the steam was confined in the cylinder until the piston had reached the end of its stroke, there would not be time, nor will it be possible, with a slide-valve and link-motion, to secure a sufficiently large opening of the port to permit the steam to escape from the cylinder before the piston begins its return stroke. If there were no pre-release, there would therefore be more or less back pressure on the piston.

QUESTION 357. *Upon what does the amount of pre-release depend?*

Answer. First, as has already been explained in answer to Question 125, on the amount of inside lap; and, second, on the outside lap of the valve and lead of the eccentrics; and, third, on the travel of the valve. The less the inside lap, the greater the outside lap and consequent lead of the eccentrics, and the shorter the travel of the valve, the earlier will be the release. The proper amount of this pre-release depends upon the velocity of the piston and the quantity of steam to be discharged or the degree of expansion. From the motion-curves in fig. 227 it will be seen that it is a marked feature of the shifting-link mo-

Fig. 231.



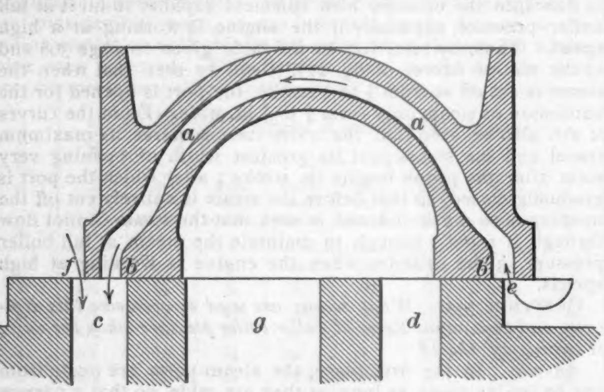


Fig. 232.

tion that the pre-release occurs earlier in the stroke as the link approaches mid-gear, or as the travel of the valve diminishes. As the link is usually worked near that position when the engine is run at a high speed, it will be seen that in this respect again the link-motion is well adapted for working the slide-valves of locomotives.

QUESTION 358. *What governs the period of release?*

Answer. The release, like pre-release, is dependent upon the amount of inside lap, the outside lap and consequent lead of the eccentrics, and the travel of the valve. The addition of inside lap has the effect of closing the port earlier than it would be closed without, and thus shortening the period of release and also of reducing the area of the opening of the port.

With the same travel, increase of outside lap and lead shortens the period of release, but has no effect on the width of the opening of the port to the exhaust.

Increase of travel, with the same outside lap, lengthens the period of release and also increases the width of the opening of the port to the exhaust.

QUESTION 359. *What governs the period of compression?*

Answer. As compression begins when release ends, or when the port is closed to the exhaust, it is controlled by exactly the same causes, and as the two events occur simultaneously, of course whatever shortens the period of release lengthens that of compression.

QUESTION 360. *What effect do the clearance spaces and steam-ways have upon the compression of the confined steam?*

Answer. By referring to the motion-curves in fig. 227, it will be seen that the steam-port is closed by the exhaust-edge of the valve, or compression begins some time before the piston reaches the end of the stroke. The result is that the remaining portion of the cylinder, through which the piston must move *after* the port is closed to the exhaust, is filled with steam of atmospheric pressure, or possibly a little above that pressure. As this is confined in the cylinder, it is compressed by the advance of the piston. If there was no room between it and the

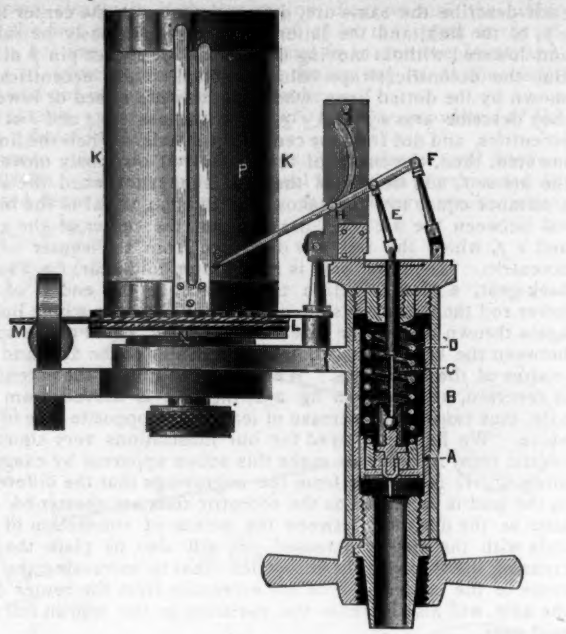


Fig. 233.

cylinder at the end of the stroke, then either the cylinder would be burst or the valve would lift so as to allow the compressed steam to flow back into the steam-chest. The clearance and the steam-passages, however, afford considerable room, into which the confined steam can be compressed without danger of bursting the cylinder or of raising the slide-valve when there is steam in the steam-chest. As the clearance spaces and steam-ways must be filled with high-pressure steam at the beginning of each stroke, it must be obtained either by taking a supply of "*live*" * steam from the steam-chest, or by compressing into the clearance spaces the low-pressure steam that still remained in the cylinder when the port was closed to the exhaust. By the latter process, a certain quantity of steam is saved at the expense of increased back pressure. It should be borne in mind also that the total heat of the compressed steam increases with its pressure, and as its pressure approaches that in the boiler, its temperature must also be raised from that due to about atmospheric pressure to near that in the boiler. These changes of temperature which the steam undergoes will affect the surface of the metal with which the steam is in contact during the period of compression; it follows from this, that the ends of the cylinder principally comprising the clearance spaces must acquire a higher temperature than those parts where expansion only takes place. This is an important consideration, since the fresh steam from the boiler comes first in contact with these spaces, and by touching surfaces which have thus previously been heated, as it were, by the high temperature of the compressed steam, less heat will be abstracted from the fresh steam, and therefore a less amount of water will be deposited in the cylinder.†

It will thus be seen that the effect of compression is to fill the clearance spaces and steam-ways with compressed steam before pre-admission begins. As already stated, this is done at the expense of back pressure in the cylinder. It must be remembered that all the energy, excepting that part which is wasted by loss of heat, friction, etc., which is consumed in compressing the confined steam, is again given out to the piston by expansion. The confined steam also acts as an elastic cushion to receive the piston, just as the steam which is admitted before the end of the stroke would if there were no compression. Compression, therefore, has the effect of saving the quantity of live steam which it would otherwise be necessary to admit before the end of the stroke to fill the clearance spaces and steam-ways,

* The term "live" steam means steam taken direct from the boiler and which has not been used in the cylinder or to do any work.

† Bauschinger's Indicator Experiments on Locomotives.

and also to "cushion" the piston. As already stated, the momentum of the piston and other parts depends upon their weight and the speed at which they are working, increasing directly as the square of the speed, from which it follows that the compression should increase rapidly with the speed and should be the greatest at high speeds. As the ports are prematurely closed to the exhaust with the shifting-link motion, and as the lead increases rapidly as the link approaches mid-gear, and the amount of compression is at the same time correspondingly augmented, it will be seen that the shifting-link motion fulfills these conditions very perfectly.

The pressure to which the confined steam will rise depends, of course, upon the amount of the period of compression, and also on the size of the clearance spaces. As it is possible to have such an amount of compression that it will exceed the boiler pressure, and thus raise the valve from its seat and be forced back into the steam-chest, some care must be exercised to proportion the one to the other, so that the degree of the confined steam may not be excessive.

QUESTION 361. *How can the effect of the distribution of the steam upon its action in the cylinder be determined by experiment?*

Answer. As already explained in answer to Question 88, this can be done by an instrument called a steam-indicator.

multaneously with the position of the piston; the latter must travel while the action is taking place, and thus the diagram shows changes of pressure later or more gradually than they occur.* To overcome these and other difficulties, the piston-rod of the indicator which we have illustrated is attached by a link, *E*, to the lever *F G*, which carries a pencil, *G*. By this means the piston has only one fourth of the motion that it imparts to the pencil, so that the momentum of the moving parts is comparatively slight.

In order that the pencil may draw a straight line instead of a curved one, a roller is attached to the lever at *H*. This moves in a curved slot, *H I*, which causes the end *G* to move in a straight line instead of the arc of a circle. The levers and all the parts, are, of course, all made as light as possible, so that their weight will have little effect on the motion of the indicator piston.

The paper or card, *P P*, on which the diagram is drawn, is wrapped around a brass cylinder, *K K*. This cylinder is made to revolve part of the way around by a strong twine, *L M*, which is wrapped around a pully, *N*, at the bottom of the cylinder. The twine is attached to a lever, similar to that shown in fig. 38, which receives a reciprocating motion from the piston of the engine. The twine can, of course, move the cylinder

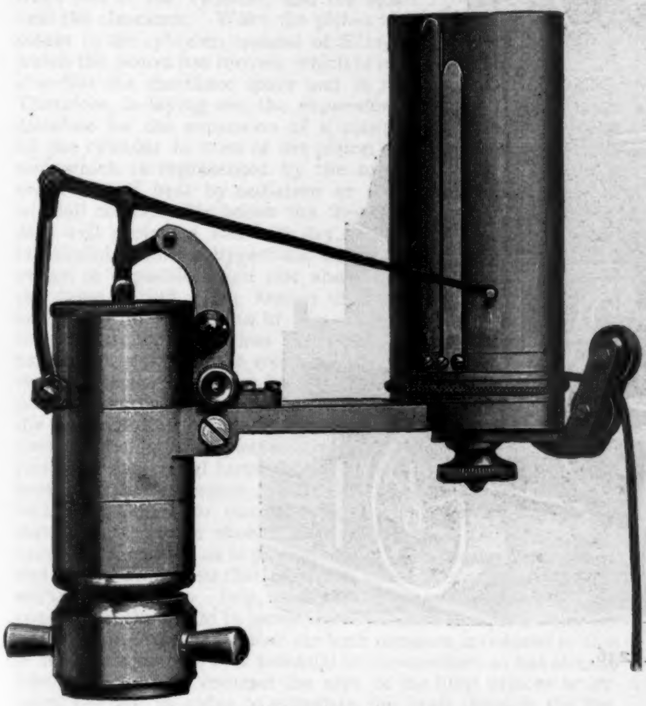


Fig. 234.

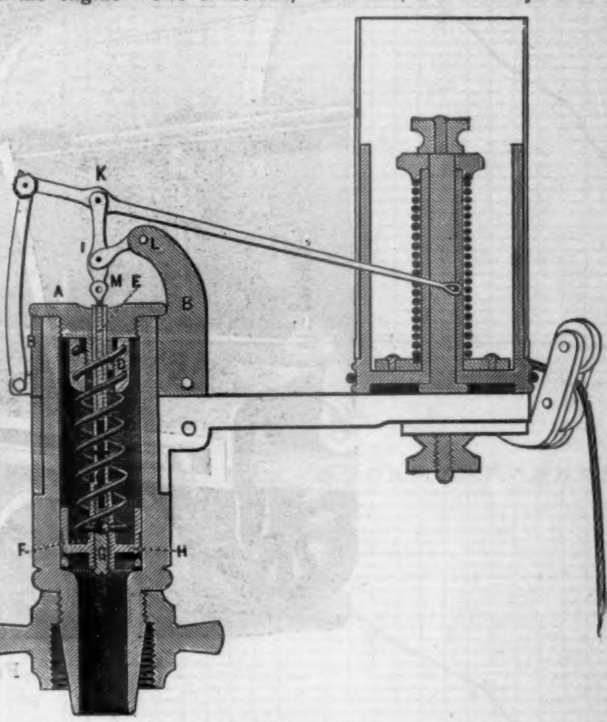


Fig. 235.

QUESTION 362. *What is the construction of this instrument?*

Answer. Fig. 233 represents the Tabor indicator.* It consists of a cylinder, *B* (which is shown in section), into which a piston, *A*, is accurately fitted, but so that it will move freely in the cylinder. The piston-rod *C* is surrounded with a spiral spring, *D*, the lower end of which is attached to the top of the piston, and the upper end to the cylinder cover. When steam is introduced below the piston it pushes it up in the cylinder, and the spring is compressed. If there should be a vacuum below the piston, the air above it will press the piston downward and extend the spring. This latter occurs only when the indicator is used on condensing engines. Of course the distance which the piston is forced up by the steam-pressure below it depends upon the amount of pressure and also on the tension of the spring; and therefore if a pencil was attached to the piston-rod so that it could mark on a moving card in front of it, a diagram would be drawn, which would indicate the steam-pressure, as was explained in answer to Question 88. But there are some practical difficulties in the way of doing this. It is found that if the pencil is attached directly to the piston-rod of the indicator, the distance through which they must move, in order to make the scale of the diagram sufficiently large to be clear, is so great that the momentum of the parts carries them farther than the pressure of the steam alone would move them. The distance through which the piston would move, moreover, makes it impossible that the changes of pressure should be indicated si-

* Manufactured by the Ashcroft Manufacturing Company, 111 Liberty Street, New York.

only in one direction, and therefore a coiled spring similar to a clock spring is placed inside of the cylinder to draw it back when the twine is relaxed. In this way the paper cylinder or drum receives a part of a revolution at each stroke of the piston and moves simultaneously with it. This drum is used instead of a flat card shown in fig. 38. The motion of the paper on this drum will, however, be exactly the same in relation to the pencil as the motion of a flat card would be.

Fig. 234 is an outside view, and fig. 235 a section of the Crosby † indicator, which is similar to the one just described, excepting the mechanism for producing a rectillinear motion of the pencil, which differs somewhat from the other, as is shown in the engravings.

The method of attaching an indicator to a locomotive is represented in fig. 236. It will be seen from this that it is placed over the middle of the steam-chest and is connected to each end of the cylinder with ½-in. pipes. A three-way cock is placed at the point A where the horizontal pipe connects with the vertical one leading to the indicator, by which steam can be entirely shut off from the indicator or communication can be established with either end of the cylinder. The arrangement of the levers for giving motion to the indicator drum and that of the seat, which is very requisite for the experimenter, will be readily understood from the engraving without further explanation. It is thought by some engineers that the indicator

* Richards's Steam Indicator, by Charles T. Porter.

† Manufactured by the Crosby Steam Gage & Valve Company, of Boston.

should be applied as near to each end of the cylinder as possible. It is believed, though, that if the pipes, cocks, and their connections are made large enough so as not to impede the motion of the steam, no appreciable error will arise from the method illustrated in fig. 236.

QUESTION 363. *What is the form of an indicator diagram?*

Answer. This depends upon the pressure of the steam, the action and proportions of the valve, the speed of the engine, and a variety of other circumstances. To show the influence of the action of the valve, it will be supposed that an indicator diagram is taken with a valve like that shown in fig. 49, and that its movement is represented by the two motion-curves shown by heavy lines in fig. 218.

It should be explained, first, that with ordinary indicators the size of the diagrams is from 3 to 4 in. long and 1½ to 2 in. wide. Therefore the springs which resist the steam pressure under the indicator-piston are made of varying degrees of tension, which are designated as Nos. 4, 8, 12, 16, 20, 30, 40, 50, 60, 80, 100. The number of the spring represents the pressure

and the steam escapes, so that the pressure is rapidly reduced, and the spring above the indicator-piston forces it down and the pencil draws the line *C D E*. *C* is called the "*point of release*," and *C D E* the "*exhaust line*."

During the return stroke of the piston, not all the steam escapes from the cylinder, and, especially if the speed is rapid, there is more or less "*back pressure*," as it is called, in front of the piston, which causes the pencil to draw a line, *E F*, called the "*back-pressure line*," somewhat above the atmospheric line, *m n*. Before the piston reaches the end of its return stroke the port is closed to the exhaust, and the steam and air enclosed in the cylinder is compressed by the advancing piston, so that the indicator pencil draws the line, *F G*, called the "*compression curve*." The point *F* is called the "*point of compression*" or "*point of exhaust closure*."

Fig. 238 represents the form of diagram which would be made by the valve, if its movement was as represented by the smaller motion-curve drawn in light lines in fig. 218. In this and the following diagram the vertical lines represent inches of the stroke,

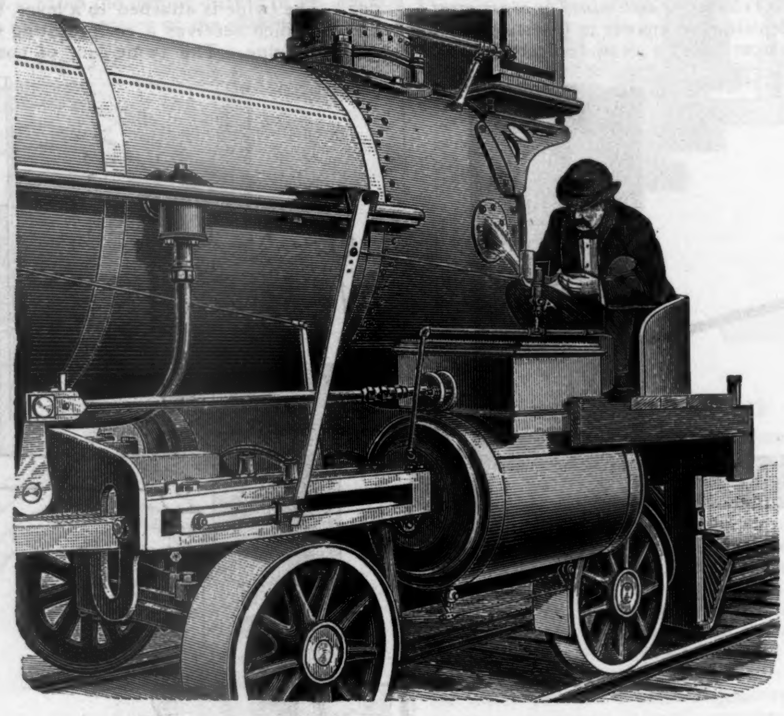


Fig. 236.

in pounds per square inch required to compress it sufficiently to move the pencil vertically 1 in. on the diagram. Therefore, by dividing the boiler pressure in pounds by the desired height of diagram in inches, the result will be the number of the spring required. A boiler pressure of 140 lbs. per square inch will be assumed, so that if the diagram is not to exceed 1¾ in. in height, a number 80 spring should be used.

Fig. 237 is supposed to represent an indicator diagram which would be made by the valve, shown in fig. 218, when its movement is as represented by the heavy motion-curve. The horizontal line *m n* represents the line which would be drawn by the pencil of the indicator if the card was moved horizontally when there is only atmospheric pressure above and below the piston. The pencil is supposed to stand at *G* at the beginning of the backward stroke of the piston. As the valve has $\frac{1}{16}$ in. lead it opens the steam-port a little before the piston reaches the end of the stroke. While the crank is moving past the dead point the valve has considerable movement, so that if the engine is moving slowly steam of full boiler pressure will be admitted into the cylinder, and the piston of the indicator will be forced upward, and the pencil will draw the line, *G A*, which is called the "*admission line*." At the beginning of the stroke the valve opens the port quickly, and it remains open until the piston has reached 21¼ in. of its stroke, and during that period the pencil draws the horizontal line, *A B*, which is called the "*steam line*." When the pencil gets to *B* the steam-port is closed and the steam is *cut off* or confined in the cylinder and then expands, and the pencil draws the line, *B C*, which is called the "*expansion curve*." *B* is therefore called "*the point of cut-off*." When the pencil reaches *C*, the exhaust-port is opened

and the horizontal lines and scale on the left the steam-pressure in pounds per square inch. It will be seen that steam is cut off at 16 in. instead of 21½ in. Release occurs at 21 in., and compression begins at a point 2 in. from the end of the stroke.

Fig. 239 is such a diagram as would be made when steam is cut off at 8 in., and in fig. 240 expansion begins at 4½ in. In order to make these diagrams clear a scale of the indicator spring is drawn on the left side of the engraving, and the horizontal lines on the diagram represent the steam-pressure, and the vertical lines indicate inches of the stroke of the piston.

QUESTION 364. *What should be the form of an indicator diagram, if the steam is distributed by a link-motion so as to produce the best practicable action in the cylinders?*

Answer. It should approximate to that shown in fig. 241. The atmospheric and vacuum lines *m n* and *o p* are indicated, as already explained. The points at which the different periods of the distribution begin are indicated by small circles, and the letters *A*, *B*, *C*, *D*, *E*, *F*, *G*, and *H*.

The diagram represents a distribution of steam produced by a valve having ⅞ in. outside and $\frac{1}{16}$ inside lap. The eccentrics have 5 in. throw, and the steam-ports are 1½ and the exhaust 2⅝ in. wide. The valve is cutting off at 8 in., or one-third of the stroke. Pre-admission begins at *G*. when the piston still has 1 in. to move before reaching the end of its stroke. Admission, of course, begins with the stroke, expansion at 8 in., release or exhaust at 17 in., and compression at 16 in. of the return stroke. The valve is supposed to be set with $\frac{1}{16}$ in. lead at full stroke. When the steam is cut off at 8 in. of the stroke, the valve has 2⅝ in. travel and ¼ in. lead. The steam-pressure in the boiler is supposed to be 140 lbs. above the at-

mosphere. Of course when the valve cuts off at different points of the stroke, the periods of distribution will be somewhat changed; but from the above diagram the principal features of a good distribution can be explained.

These are: First, that the steam-pressure should rise rapidly during the period of pre-admission, so that there will be nearly full boiler pressure in the cylinder at the beginning of the stroke. When this occurs, the pre-admission line will rise from *G* to such a point as will indicate nearly or quite full boiler pressure in the cylinder. The same pressure should then be maintained in the cylinder during the whole period of admission, and the admission line from *A* to *B* should therefore approximate to a straight horizontal line. When expansion begins, the pressure will fall, as was explained in answer to Question 88. The expansion line should approximate to a hyperbolic curve, but in laying out this curve allowance must be made for the clearance space between the piston and cylinder heads and the contents of the steam-ways. The cubical contents of these at each end of the cylinders of locomotives are usually from 5 to 10 per cent. of the space swept through by the piston. It will be assumed that this is equal to the space swept by the piston in moving two inches. A line, *I J*, is therefore drawn, two inches from *A O*, which represents the front end of the cylinder, and the space *I J O A* will represent the clearance. When the piston has moved 8 in., then, the steam in the cylinder, instead of filling only the space through which the piston has moved, which is represented by *A O K B*, also fills the clearance space and is represented by *I J K B*. Therefore, in laying out the expansion curve, *B C r*, we must calculate for the expansion of a quantity of steam sufficient to fill the cylinder in front of the piston *and* the clearance spaces, and which is represented by the area *I J K B*. If there is much loss of heat by radiation or other causes, the diagram will fall considerably below the theoretical curve. With cylinders well protected and with dry steam the expansion line will fall slightly below a hyperbolic curve at the beginning of the period of expansion, and rise above it during the latter part of the same period. The reason of this is that the cylinder is heated by the admission of live steam of comparatively high temperature, so that when the pressure becomes reduced by expansion, a part of the water which is condensed in the cylinder will be re-evaporated by the heat in the latter. From the point of the release or exhaust, *C*, to the end of the stroke *D*, the exhaust line should fall rapidly, so that there will be no pressure behind the piston during its return stroke. To explain the theoretical form of the exhaust line would lead into a very abstruse discussion, which would be out of place here. It will be sufficient for our purpose to call attention to the fact that the pre-release should allow as much of the steam in the cylinder to escape as is possible before the piston reaches the end of the stroke, so that the back pressure during the return stroke may be low. It is, however, only at comparatively slow speeds that the steam in locomotive cylinders escapes during the period of pre-release, so that the back pressure is reduced to that of the atmosphere. It is essential in locomotives, as has already been explained, to contract the area of the blast orifices or exhaust nozzles, in order to stimulate the draft through the fire, so that the steam cannot escape with sufficient rapidity to reduce the back pressure to that of the atmosphere if the engine is running fast. Of course every pound of back pressure on the piston is equivalent to an equal amount deducted from the effective pressure on the other side.

QUESTION 365. *How can the net effective pressure on the piston be shown by indicator diagrams?*

Answer. This can be done by taking two indicator diagrams on the same card from opposite ends of the cylinder, as shown in fig. 242. The area *A B C D P O* and *A' B' C' D' O P* represent the absolute pressures in front of the piston during the backward and forward strokes. The areas *H G F E D P O* and *H' G' F' E' D' O P* represent the absolute pressures on the opposite side of the piston or the back pressure. As the one must be deducted from the other to get the net pressure we have *A B C* 2 *F F G H* and *A' B' C* 1 *F F' G H'* as the areas which represent the net forward pressure on the piston. At each end of the stroke the back pressure exceeds the forward pressure, and therefore we have the two areas *H* 1 *D'* and *H'* 2 *D*, shaded black, which represent the retarding effect on the piston at each end of the stroke. The length of the vertical lines between the curves *A B C* 2 and *H G F F'* 2 will give the effective pressure, and similar measurements on the black areas will give the retarding pressures for any point of the stroke. This will be made still clearer if we take a line, *H D*, fig. 243, as the line of no pressure on the piston and then lay off vertical lines equal in length to those between the curves *A B C* 2 and *H G F F* 2 of fig. 242, and draw a curve *A B C* 2, fig. 243, through their extremities. This curve will represent the net pressure on the piston, and by laying off vertical lines below *H D* equal in length to those in

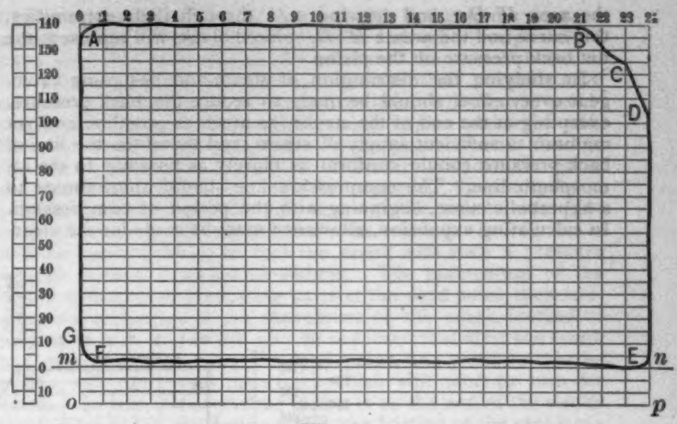


Fig. 237.

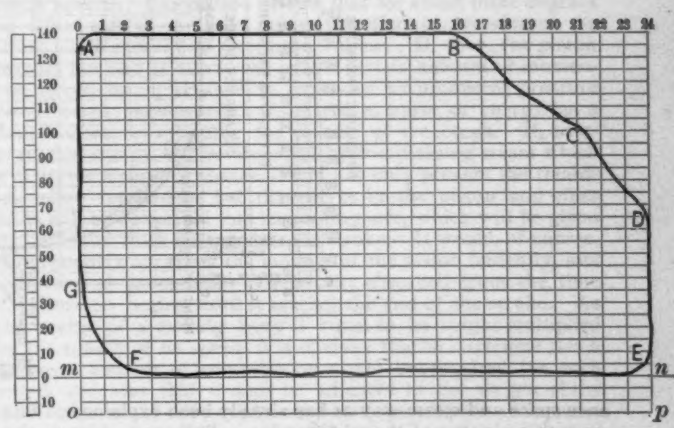


Fig. 238.

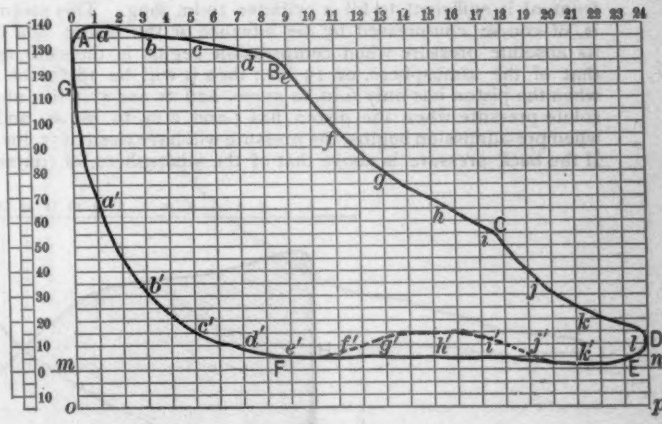


Fig. 239.

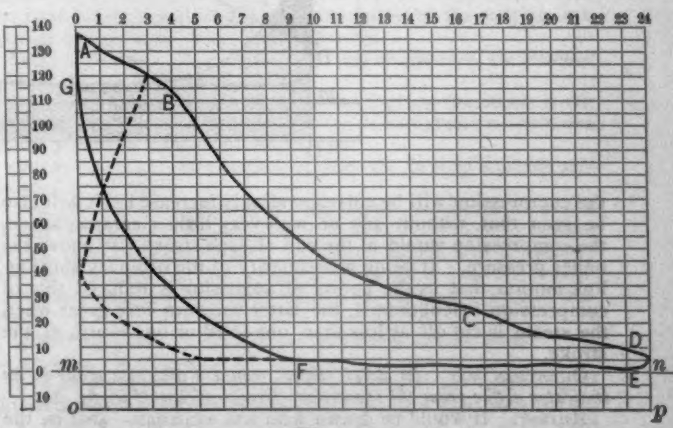


Fig. 240.

the area $H\ D$ 2, and drawing 2 H' through their extremities, this curve and the area 2 $H'\ D$, colored black, will represent the net back pressure on the piston.

In studying the distribution of steam and designing valve-gear every effort should be made to reduce the back pressure, excepting at the end of the stroke, as much as possible, and yet maintain a sufficient supply of steam, and therefore the line of back pressure should conform as closely as possible to the atmospheric line. The compression line should approximate to a hyperbolic curve, beginning with the period of compression. In calculating expansion, allowance must be made for the clearance space and steam-way as has already been explained. The same thing is true of the compression. This must occur in the above example when the piston has 8 in. more to move before completing its stroke. There is therefore a quantity of steam in front of it sufficient to fill a cylinder 10 in. long. This steam is, of course, compressed by the advance of the piston, and if its absolute pressure when compression begins is the same as that of the atmosphere, or 15 lbs., then it will be 18.75 lbs., when the piston has only 6 in. to move, and 25 and 37.5 lbs. absolute pressure when the piston has 4 and 2 in. to move, and when pre-admission begins, the pressure will have risen to 75 lbs. If the back pressure is above that of the atmosphere, of course the compression will be correspondingly increased. It will also be seen that, without any or with very little clearance space, the compression would at the end of each stroke rise above the boiler pressure. It being a peculiarity of the ordinary shifting-link motion that as the period of admission is reduced that of compression is lengthened, the latter becomes very great when the steam is cut off at less than one-third or one-fourth of the stroke.

QUESTION 366. *In what respect would a diagram made by an indicator differ from the theoretical form represented in fig.* 241?

Answer. It would be drawn with less exactness—that is, the corners instead of being sharply defined, as in fig. 241, would be more or less rounded, as shown in figs. 237 to 240, and the curves and lines would vary somewhat from the exact mathematical form indicated in fig. 241. The higher the speed at which the engine is working when the diagrams are taken, the greater will be the variation from the theoretical form.

QUESTION 367. *If the amount of pre-admission is insufficient, how will it be shown in the indicator diagram?*

Answer. The effect of too little pre-admission is to lower the pressure of the steam at the beginning of the stroke, and at high speeds there will not be time enough nor sufficient opening of the steam-port to supply the deficiency after the stroke has commenced. The effect of this is shown by the dotted lines in fig. 240, which show that full pressure was not reached until some time after the beginning of the stroke. With a link-motion if steam is cut off short the port is opened but a small distance, which is sufficient to maintain the pressure at the beginning of the stroke, when the piston is moving comparatively slowly. But when the piston has moved a short distance, its motion is accelerated and the port is being gradually closed by the valve, and the area available for the admission of the steam is gradually diminished. Consequently, the steam cannot enter fast enough to follow the piston, and the pressure falls, so that the admission line, $A\ B$, is no longer horizontal, but droops, as shown in figs. 239 and 240.

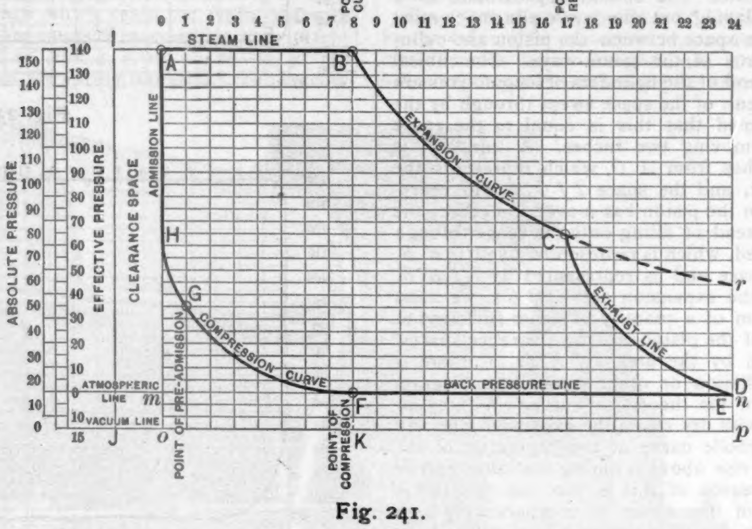


Fig. 241.

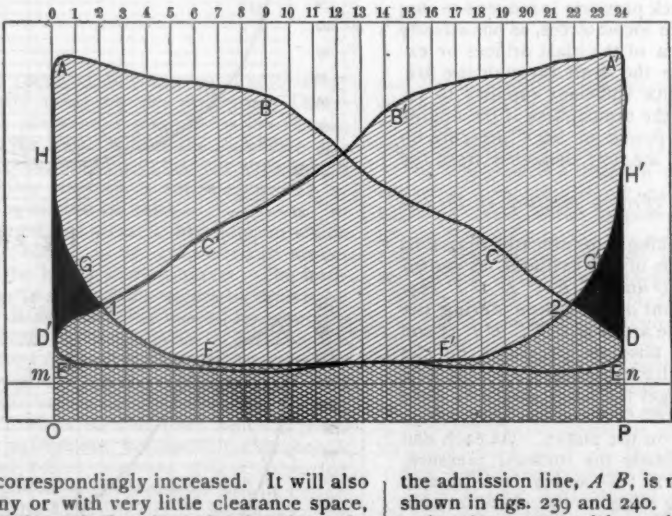


Fig. 242

Another cause of loss of pressure at the commencement of the stroke, when the steam is worked expansively, is the partial condensation of the entering steam, which takes place in consequence of its coming in contact with the sides of the port and walls of the cylinder, which have been previously cooled down by contact with the exhaust steam of the preceding stroke. This condensation of the fresh steam causes a very serious loss of efficiency in the steam-engine.*

* The Steam-Engine, by George C. V. Holmes.

QUESTION 368. *If the opening of the steam-ports during admission is too small, what will be the form of the diagram?*

Answer. The effect will be very much the same as that produced by too little pre-admission or lead—that is, the pressure in the cylinder will be much lower than in the boiler and will fall rapidly during the periods of admission, as shown in fig. 240.

QUESTION 369. *What defects will be indicated by the expansion curve of indicator diagrams?*

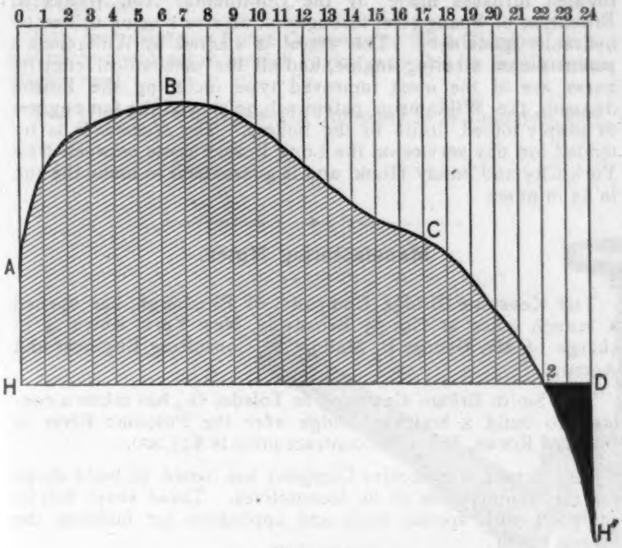


Fig. 243.

Answer. If the cylinders are not well protected, and there is much loss of heat from radiation, there will be a rapid fall of pressure during the period of expansion, which will be shown by the expansion curve falling below the theoretical curve. If, on the contrary, the indicator curve is much above the theoretical curve, it may be caused by a leak in the valve. As steam is quite as likely to leak from the steam-port into the exhaust as from the steam-chest into the steam-port, a valve which is not tight may produce just the contrary effect upon the indicator diagram. As it is usually quite easy to detect a leak in the valve by other means, the use of the indicator for this purpose is unnecessary. Attention is called to it, however, to show the impossibility of getting results of any value with the indicator if the valves are not steam-tight.

QUESTION 370. *What should be observed regarding the exhaust line of the indicator diagram?*

Answer. The most important point to be observed is, whether the pressure at the end of the stroke is reduced as low as possible, as at high speeds it is usually much more difficult to exhaust the steam from than to admit it into the cylinder. As already stated, the blast in the chimney makes it almost impossible to exhaust the steam to atmospheric pressure when the locomotive is running fast. If the steam is released too late in the stroke, as already explained, there will not be time enough nor sufficient opening of the port to allow the confined steam to escape from the cylinder before the end of the stroke, and this will be indicated on the diagram by the space between the line of back pressure and the atmospheric line during the commencement of the return stroke, as shown in figs. 242, 244.

QUESTION 371. *What should be observed regarding the line of back pressure?*

Answer. The most important point is, that it should approximate as closely as possible to the atmospheric line, as all the back pressure not only diminishes the efficiency of the engine, but is a total loss of energy. Too much inside lap will increase the amount of back pressure, but generally it is more influenced by the area of the blast orifices than by any other cause. Every effort should be made, therefore, to have them as large as possible, and yet have the boiler make as much steam as is needed.

When only one blast orifice is used for both cylinders, it often happens that when the steam is exhausted from the one cylinder it "blows" over into the other, and thus produces an additional amount of back pressure. This is shown by a rise or "hump" in the line of back pressure, as indicated by the dotted line $f\ g'\ h'\ i'\ j$ in fig. 239.

QUESTION 372. *What good effects result from compression?*

Answer. It serves to arrest the motion of the piston at the end of the stroke. As was explained in Chapter VIII. the motion of a piston in the cylinder of a steam-engine is not a uniform one, but increases in speed from the beginning of the stroke to the middle, and diminishes in speed from the middle to the opposite end. It is obvious that if the momentum, or actual energy stored up in the piston and other reciprocating parts after they have passed the middle of the stroke, added to the pressure behind the piston, is greater than the resistance offered by the crank, the motion of the latter will then be accelerated and thus conveyed to the moving engine and train. If, however, there is any momentum in the piston when it reaches the end of the stroke, evidently it can exert no power to cause the crank to revolve, but must be expended by producing a pressure on the crank-pin and thus on the axle-boxes. Not only will such a pressure not cause the crank to revolve, but it will be more difficult to turn the crank with such a pressure against it than it would be without. The momentum of the piston and other reciprocating parts at the dead point, therefore, creates a resistance to the movement of the crank instead of helping to turn it. It will also be observed that after the crank has moved slightly from the dead point, any pressure on the piston will exert very little force which will tend to turn the crank. In fact, the nearer the piston is to the end of the stroke the greater is the proportion which the friction of the crank-pin and axle bears to the useful effect of the strain in causing the crank to turn. Calculation shows that for about three degrees on either side of the dead points the effect of pressure on the crank-pin is actually to retard the engine. If, then, the piston reaches the end of the stroke with a certain amount of momentum stored up in it, which is expended by producing pressure on the crank, then it will not only be a waste of energy but a double waste by retarding the motion of the crank. If, however, this energy can be absorbed by compressing steam which will fill the clearance spaces, it will not only prevent the retarding effect referred to, but the energy in the piston and other parts will be converted into steam pressure, which will be given out in useful work during the next stroke. It would, of course, be impossible to arrest the motion of the piston instantly, and therefore its momentum is gradually absorbed from the time compression begins until it reaches the end of the stroke. As the energy of a moving body is equal to its weight multiplied by the square of its speed, it is obvious that to overcome this a different amount of compression would be required for each speed, and also that it must be adjusted to the weight of the moving parts. Such adaptation is not practicable on locomotives, nor does the link-motion enable us to alter the amount of compression with so much exactness; but the explanation

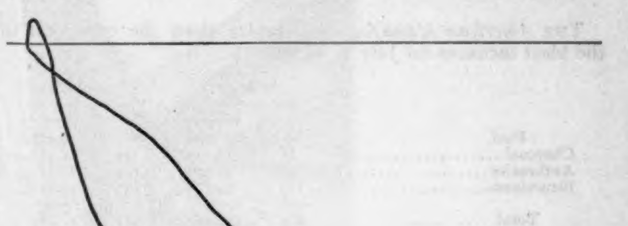


Fig. 244.

shows the value of increasing the amount of compression with the speed, which fortunately the peculiarities of the shifting-link motion enable us to do without difficulty.

QUESTION 373. *How does a link-motion increase the amount of compression with the speed?*

Answer. When a locomotive is running fast the steam is cut off short, and the lead and the amount of compression increases as the period of admission diminishes.

QUESTION 374. *What cause produces the form of diagram represented by fig. 244?*

Answer. It is produced by excessive compression, which causes the pressure in the cylinder to rise above boiler pressure before pre-admission begins. As soon as the port is opened, part of the steam in the cylinder flows back into the steam-chest, and thus the pressure is reduced, as shown by the diagram.

QUESTION 375. *What will an indicator diagram show?*

Answer. It will show:

1. The pressure of steam in the cylinder at the beginning of the stroke of the piston, or the *initial pressure*, as it is called.

2. Whether the initial pressure is increased or diminished during the period of admission.

3. The point of cut-off.
4. The pressure during the whole period of expansion.
5. The point of release—*i.e.*, when the exhaust is opened.
6. The rapidity with which the exhaust takes place.
7. The back pressure on the piston.
8. The point at which the exhaust is closed.
9. The compression after the exhaust is closed.
10. The power which is driving the engine.
11. Leakage of the valve or piston.

QUESTION 376. *What are the principal causes which affect the form of the diagram?*

Answer. 1. The friction of the steam in the pipes and ports.
2. The variable size of the openings of the steam-ports as caused by the gradual motion of the slide-valve.
3. The action of the internal surfaces of the cylinder in causing condensation and partial re-evaporation of some of the entering steam.
4. The steam contained in the clearance spaces which affects the curve of expansion.
5. The gradual opening of the exhaust-port, which makes it necessary to release the steam too early in the stroke.

(TO BE CONTINUED.)

Manufactures.

Electric Street Railroads.

THE People's Railroad Company in Scranton, Pa., which operates 12 miles of track, has ordered 20 new cars equipped with the Sprague electric motor, and also the necessary stationary plant.

THE Thomson-Houston Electric Company, of Boston, has bought the Hoosac Valley Street Railroad, running from South Adams to North Adams, Mass., and will put up a large electric plant. The road will be run by electricity, and opportunity will be taken to experiment with different motors.

Blast Furnaces of the United States.

THE *American Manufacturer's* tables show the condition of the blast furnaces on July 1, as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	68	12,753	104	12,161
Anthracite	96	28,176	104	27,173
Bituminous	119	74,743	103	52,743
Total	283	115,672	311	92,077

There was a decrease of 15 furnaces in blast and 7,343 tons capacity during June. The number of furnaces in blast, as compared with that a year ago, was as follows:

	July 1, 1888.		July 1, 1887.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	68	12,753	77	13,969
Anthracite	96	28,175	136	37,662
Bituminous	119	74,743	101	57,355
Total	283	115,672	314	108,986

The total production of pig-iron for the first half of 1888 is estimated at 2,950,000 tons, a decrease of about 99,000 tons as compared with the first half of 1887.

Marine Engineering.

THE new steamer *Monmouth*, built at Cramp's yard in Philadelphia, for the Central Railroad Company of New Jersey, has just been put in service. The new vessel is sponson built and schooner rigged, 260 ft. long, 35 ft. extreme beam, and 15 ft. 9 in. deep. Her registered tonnage is 1,490 and draft of water 10 ft. aft and 9 ft. forward. She has main, promenade, and hurricane decks. The arrangements for the comfort of passengers are tasteful and commodious. Her saloon is finished in antique oak, handsomely carpeted, having large private apartments opening into the main saloon, and some 30 private rooms for the accommodation of those desiring them. The vessel is lighted throughout with the incandescent electric light. She will be allowed 2,200 passengers.

The machinery consists of a pair of the most modern designed, vertical, triple-expansion twin-screw engines. The cylinders are 19, 30, and 50 in. diameter by 30 in. stroke of piston, and are expected to develop 2,500 H.P. with a steam pressure of 160 lbs. Piston slide-valves on all the cylinders are worked by the Marshall valve-gear; the air pumps are driven off side-levers and the centrifugal circulating pumps by independent engines. The boilers are four in number, 12 ft. diameter by 12 ft. 5 in. long, fitted with Montgomery patent corrugated furnaces made by the Continental Iron Works of Brooklyn, of Spang steel throughout, all rivets being drilled by hydraulic machinery. The vessel is steered by Williamson's patent steam steering-engine, and all the mechanical contrivances are of the most improved type including the Edison dynamo, the Williamson patent ash-hoist, and the fan engines to supply forced drafts to the boilers. The *Monmouth* is intended for day service on the Long Branch route between New York City and Sandy Hook, and is guaranteed to make the run in 55 minutes.

Manufacturing Notes.

THE Keystone Bridge Company, of Pittsburgh, has opened a branch office at No. 55 Broadway, New York, which is in charge of Mr. George B. Mallory as Consulting Engineer and Agent.

THE Smith Bridge Company in Toledo, O., has taken a contract to build a highway bridge over the Potomac River at Point of Rocks, Md.; the contract price is $45,000.

THE Strong Locomotive Company has voted to build shops for the manufacture of its locomotives. These shops will be equipped with special tools and appliances for building the Strong boiler.

THE Rogers Locomotive Works in Paterson, N. J., have recently completed three engines for the Nashville, Chattanooga & St. Louis and seven for the Long Island road; also several heavy passenger engines, with Wootten fire-box, for the Union Pacific.

THE Schenectady Locomotive Works in Schenectady, N. Y., are building a new shop 75×350 ft. These works in June turned out 28 locomotives, as follows: Three 18×24 passenger, and four 20×26 consolidation freight locomotives for the New York Central & Hudson River Railroad; two 18×24 passenger for the Indianapolis & St. Louis; six 17×54 wheel switchers; six 18×22 passenger, and six 18×24 wheel freight locomotives for the Chicago, St. Paul, Minneapolis & Omaha; one 17×24, 8-wheel locomotive for the Meriden, Waterbury & Connecticut River Railroad. The works are employing about 1,400 men.

THE firm of Binsse & Hauschild, of East Newark, N. J., have received the award of one-half of the gun lathes for finishing the parts of the new steel breech-loading rifle guns, the remainder to be awarded when these are completed. These guns are to form the armament of the men-of-war now building. The six lathes for finishing the tubes are to be 130 ft. long each; the three lathes for the jackets are 64 ft. long each, and the seven hoop lathes are about 40 ft. long each. All these tools swing 9 ft. over the bed and 9 ft. across the bed. The hoop lathes will weigh about 100,000 lbs. each. The main spindle bearing is 12 by 20 in., and the face plate, 9 ft. in diameter, will weigh about 10,000 lbs. The beds, two for each machine, will be about 40 ft. long in one piece, and will weigh about 15,000 lbs. each. The tools are to be erected in the Washington Navy Yard.

Cars.

THE Chattanooga Car Works in Chattanooga, Tenn., are building a lot of coal cars for the Chattanooga, Rome & Columbus Railroad.

THE Crossen Car Works at Cobourg, Ont., have recently completed a very handsome sleeping-car for the Intercolonial road.

THE Wason Manufacturing Company at Springfield, Mass., is building several drawing-room cars for the New York, New Haven & Hartford road.

THE St. Charles Car Company at St. Charles, Mo., is building 1,000 freight cars for the Atchison, Topeka & Santa Fé Railroad.

THE new shops which the Canadian Pacific Company is now building in Montreal include a passenger car shop 400 ft. in

diameter and two stories high; wood machinery shop, 400×100 ft., two stories high; blacksmith and machine shop, 300×100 ft., one story; store room, 350×90 ft., two stories high, and a foundry, 150×100 ft., two stories high, all of which are to be built of brick and stone, and which, for the buildings alone, will cost about $300,000. When completed these works will give employment to about 1,000 hands.

THE Missouri Car & Foundry Company in St. Louis has received an order for 735 freight cars for the Louisville & Nashville Railroad.

THE New Glasgow Forge Company at New Glasgow, N. S., has taken a contract to furnish 10,000 car axles for the Canadian Pacific road.

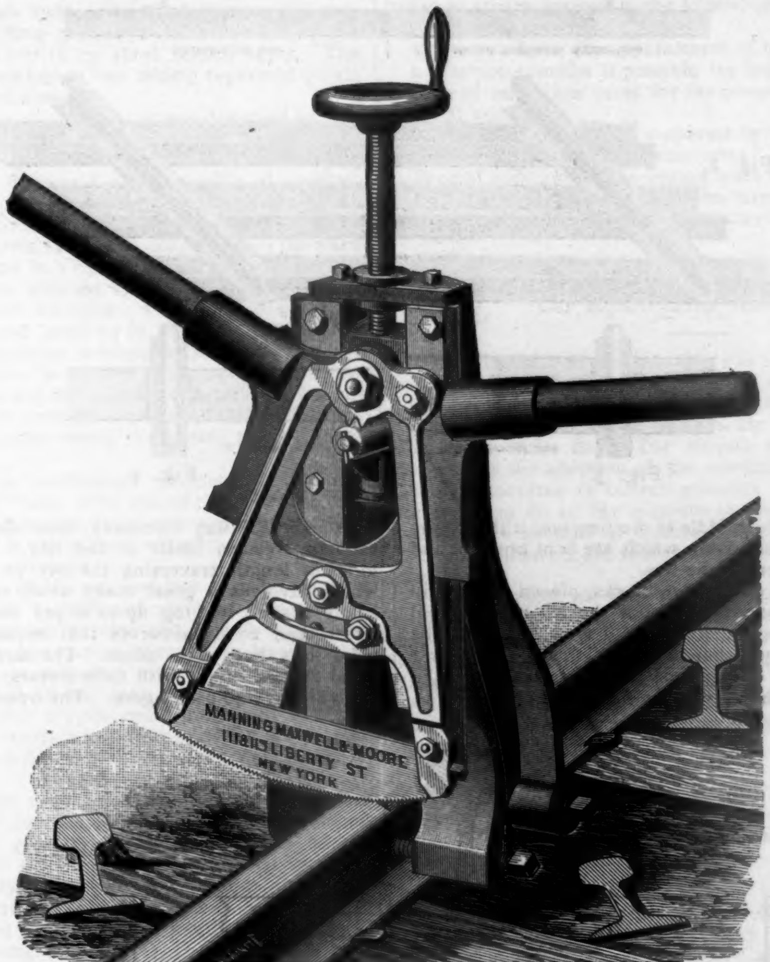
THE Harlan & Hollingsworth Company in Wilmington, Del., delivered three sleeping-coaches to the Boston & Albany Railroad early in July.

THE Fitchburg Railroad Company has begun work on its extensive new car shops at East Fitchburg, Mass. There are to be six buildings in all. Four of them will be placed side by side, and will each be 100 ft. wide by 480 ft. long, covering about $1\frac{1}{2}$ acres, and divided by two cross-walls into three equal sections of 160 ft. each. The first shop will be for car repairs, the next for building freight cars, the third for new passenger coaches, and the fourth for a paint shop. Large transfer tables will be put in between the repair shop and the freight car shop, and between the passenger car and paint shops. Some 15 or 20 tracks will be laid in each shop longitudinally, and by means of the transfer tables a car can be run in or out of either of the shops without interfering with any other car. Across the spur track will be two other buildings, one, 60 ft. by 300, for the wood-working department, and the other, 60 ft. by 400, will be the machine shop, engine, and boiler house. All of the buildings will be of brick, and, with one exception, one story in height, with a monitor roof; the wood-working shop will be two stories high. It is not proposed to erect all the buildings at once, but work will begin on the freight car shop, and will be pushed forward as rapidly as possible, for the increasing business of the road urgently demands largely increased facilities for building and repairing cars.

RIEHLE BROTHERS, in Philadelphia, have recently received orders for one 200-ton and one 50-ton track scale, one transverse tester, several cement testers, and a large number of small scales and testing-machines.

The Smith Portable Rail-Saw.

THE accompanying illustration shows a very valuable machine, intended to cut rails on the track or elsewhere, and to do away with the present method of using the chisel and sledge, thus avoiding not only the extra labor and risk of breakage but the danger of injury to the rail itself. By the use of the saw a very nice adjustment in the length of the rail can be made while the ends are left smooth and square.



SMITH'S PATENT PORTABLE RAIL-SAW.

The machine itself is so simple, and its construction is so plainly shown by the engraving that a lengthy description is hardly necessary. The first saw of this kind was made in 1885, and at that time the inventor cut with it a 60-lb. rail in 35 minutes. In its present perfected form it is claimed that a 70-lb. rail can be cut through in about 12 minutes, and that as thin a cut as $\frac{1}{8}$ in. can be taken off.

The saw-blade is carried on pins in the frame, and is made stiff by a nut shown on the end of the frame in the engraving. A saw can be removed and a new one put in very quickly when required.

This machine is in use on a number of prominent roads, and has so far met with approval wherever it has been tried.

This rail-saw was invented by Mr. S. C. Smith, of Brooklyn, N. Y., and is manufactured and sold by Messrs. Manning, Maxwell & Moore, of New York.

The Standard Metal Tie.

THE engravings herewith illustrate a new metal railroad tie which the Standard Metal Tie & Construction Company, of 155 Broadway, New York, is now introducing. As shown by the engravings, each tie is made of a plate of iron or steel ¼ in. thick, which is bent or rolled so that its cross section forms a U-shaped section, shown in figs. 5 and 6. To prevent these ties from moving laterally on the track, a portion of the bottom of each of them is cut away, as shown in figs. 3 and 4. The metal plate next to the opening, which is thus made in the base of the tie, is then bent upward, as shown at *a*, fig. 1, and also in the perspective view, fig. 2. The ballast is rammed into the openings thus formed in the middle of the ties, and it thus bears against the portions of the plates which are bent upward, and resists the lateral movement of the ties.

Fig. 1.

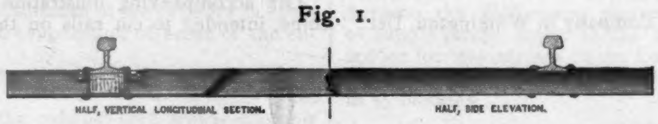


Fig. 2.

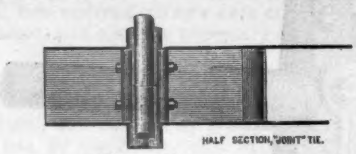


Fig. 3.

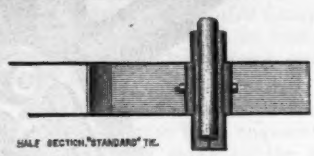


Fig. 4.

The rails are supported on wooden blocks, placed endwise in the trough of each tie, as shown under the left-hand rail in fig. 1, and at *A* in the enlarged sectional view, fig. 6. The rails are held in position by S-shaped clips, *C C*, fig. 6, the lower ends of which hook into openings, *D D*, in the bottom of the ties, and the upper ends hook over the flanges of the rails. A horizontal bolt, *B B'*, passes through each pair of clips and the wooden block *A*. As the clips bear on the inclined top surface of the rail flange when the bolt is screwed up, the rail, wooden block, and tie are all drawn together and securely held in place. The upper edges of the ties are notched to receive the rails, which effectually prevents them from spreading.

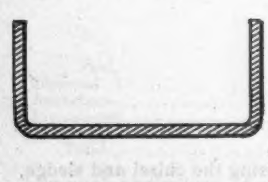


Fig. 5

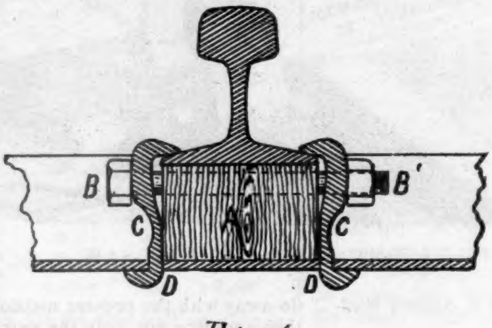


Fig. 6.

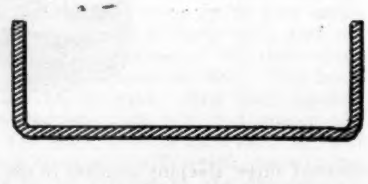


Fig. 7.

Fig. 5 shows a section of an ordinary tie, and fig. 7 one of a joint-tie. The latter are made wider than those between the joints. This increased width permits of the use of wider blocks and longer clips, which are fastened with two bolts, as shown in the perspective view, fig. 2. These clips and bolts hold the rails securely at the joints, and dispense entirely with the use of fish-plates.

The whole railroad world is now looking for a satisfactory metal tie. The increasing price and scarcity of wooden "sleepers" will soon compel railroad companies to adopt something more durable and less liable to decay than wood. Already on the Continent of Europe metal ties are extensively used, and the depletion of our forests will compel railroad managers to follow the practice of European engineers.

The Richmond Electric Railroad.

(From the *Electrical World*.)

THE Sprague electric motor is now in daily use in Richmond, Va.; the road is a double track line, operated by the Union Passenger Railway Company, from the extreme eastern to the extreme western limits of the city. The line aggregates 13 miles in length, traversing the city by a very circuitous route, which involves a great many sharp curves and several very heavy grades, ranging up to 10 per cent., while there are no fewer than 29 of the curves that require bent rails, 5 of them being less than 30 ft. radius. The cars are electrically of the usual Sprague type, with twin motors, each of 7½ H.P. Each car will carry 40 passengers. The overhead contact is used for obtaining current, by means of a light structure on top of the car. It is a low skeleton framework which carries an adjustable swiveling trunnion, having at its upper end a jaw in which is suspended a counterbalanced trolley pole, having at its extension a grooved wheel making running flexible contact on the under side of the working conductor. On getting at the end of the track this trolley trunnion is swung around so as to trend in a proper direction abaft the center of the car. It is impossible for it to pull the trolley wire down, and if off the line, it can be replaced quickly and easily. From the trolley the current passes through an insulated wire to two switches, one at each end of the car, whence it goes to the motor circuits, and thence to the wheel frame. The return circuit is through the track, and thence by both metallic and ground circuits to the station. Each section of rail is joined to a copper ground wire, which runs throughout the length of the road underneath or alongside

the stringer pieces. At intervals of 500 ft. this ground wire is connected to an earth plate, and at seven points, widely distributed, these ground plates are supplemented by heavy iron pipes sunk into iron ore or 12-in. water wells about 25 ft. deep. The ground wire is connected to the station, and there is also a main ground connection made there in a 30-ft. well through a large sink plate.

The electric circuit consists of two parts—the overhead and the ground circuits, each being of compound character. Along the curb-stones at distances of 125 ft. are 30-ft. poles inserted into the ground a distance of 5 ft. These poles carry the main circuit, which extends throughout the entire length of the road, and is of copper wire $\frac{3}{16}$ in. in diameter. This is the main conductor. The working conductor, of the same size as the main conductor, is carried over the center of the track at a distance of about 18 ft. from the ground on insulators supported by span-wires running across from pole to pole, and provided with additional insulators at their ends. The whole structure is very light looking. This working conductor is connected to the main line at intervals of 500 ft. by short branch wires. The main conductor is itself supplied at four widely separated points by feeders from the central station.

The motive-power plant of this station was designed by Mr. J. H. Vail and built by the Jarvis Engineering Company of Boston. The boilers comprise a battery of three in number, 6 ft. in diameter by 16 ft. long, and easily capable of developing 150 H.P. each; the space is also arranged for extension of the battery to admit of four more boilers of the same size. The boilers are set with the Jarvis furnace to utilize as fuel the slack soft coal which is procured in Virginia at low prices; the furnaces are lined throughout with the best fire-brick, which guarantees greater durability of the work. One large iron smoke-stack 80 ft. high above grate level, 54 in. diameter at base, and 60 in. diameter at top, furnishes a magnificent natural draft to the boilers, enabling them to be worked fully 20 per cent. above their rated capacity. The engines are of the Armington & Sims type, three in number, of nominal capacity of 125 H.P. each, and are belted to the dynamos direct, dispensing with all shafting.

The dynamos are six in number, all connected in multiple arc, feeding into a "bus" line. One side of the "bus" is connected to the ground, and to the other side are connected the feeders. Each dynamo is of 40,000 watts capacity, and is wound for a potential of 500 volts.

Owing to the character of the soil and lack of pavement the road-bed was found to be a source of much trouble; a good portion of the track being laid in mud and clay streets, which in moist weather unsettle the curves, throws the track out of gauge, and permits the accumulation of more or less soil on the rails. Steep grades of 10 per cent., and sharp curves of 27 ft. radius, combined with a 7 per cent. grade, and with the outer rail of the curve nearly 3 in. lower than the inside rail, have been found to be difficulties of no mean importance to overcome.

This road is by far the most important and extensive electric railroad enterprise ever undertaken, and has involved more difficulties and a greater variety of obstacles to the successful application of self-propelled cars, as well as to the employment of electricity, than were ever before attempted. Returns for the week ending May 9 showed an average of 20 cars out per day, running 1,548 miles, or nearly 80 miles each, and carrying 7,378 passengers, at a total cost per car for road operating expenses of \$1.98, and of \$1.48 for station expenses. In other words, the cost of operating, except official and salary charges, taxes and insurance, is only \$3.46 per car per day on an 80-mile run, and this is stated by Mr. E. P. Harris, the well-known street car expert, to be only 40 per cent. of the cost of operation by horses with the same number of cars, with the additional advantage that, in point of fact, the road with animal power, for the same work, would require not less than 25 cars, with a stable equipment of from 275 to 300 horses.

Proceedings of Societies.

Ohio Institute of Mining Engineers.

THE annual meeting was held at Logan, O., July 11 and 12. The programme included the annual address by President W. H. Jennings; and papers on the School of Mines at the State University, by Professor N. W. Lord; on Mining Legislation in Ohio, by Andrew Roy; Shaft Mining on the Sunday Creek Valley, by J. J. Dun; the Fire Clays at Five Mile Creek, by Ellis Lovejoy; the Grading of Pig-Iron, by Edward Orton, Jr. Several of these papers were discussed, and there was also a special discussion on Brick Paving.

The day after the close of the meeting the members went on an excursion, by special train, to the mines of the Hocking Valley region, including, especially, those of Sunday Creek and Brush Fork.

Engineers' Club of Kansas City.

A MEETING was held in Kansas City, June 18. It was voted to extend an invitation to the American Society of Civil Engineers, to hold its next annual convention in Kansas City. In answer to a letter from Mr. C. L. Strobel, of the Western Society of Engineers, with reference to bridge reform, it was voted to secure answers to the following questions by letter ballot from members:

1. Do you favor the appointment of bridge engineers?
2. Do you consider it possible for bridge engineers to adopt a scale of minimum rates for the proper design and specifications of bridges?
3. Are you willing to co-operate by appointing a meeting to report on the scale of minimum rates?

Several additions to the library were reported.

Mr. J. Donnelly read a paper on Street Pavements of Kansas City, which was discussed by a number of the members present.

Car Accountants' Association.

THE thirteenth annual meeting was held in Montreal, beginning on Wednesday, June 20, with a full attendance. The principal subject of discussion was the Per Diem System of Compensation for the Use of Cars, the discussion of which occupied an entire day. The subject was disposed of for the present by the adoption of the resolution instructing the Per Diem Committee to collect statistics covering the service of foreign cars on all the railroads in the United States and Canada for the months of October, 1887, March, 1888, and July, 1888; all members are requested to assist the committee in this matter.

The committee on Routing Foreign Cars presented a report making some valuable recommendations, which were generally approved. There was a long and interesting discussion including many valuable suggestions as to How the Car Service Office may be made more Efficient.

A cipher code, for use in telegraphing about car service matters, was presented by a committee. The meeting, on the whole, was a very successful one.

Engineers' Club of Philadelphia.

THE last meeting for the season was held in Philadelphia, June 16. The tellers reported the following elected members: Henry Roeske, William W. Thayer, J. H. Skinker, James S. Merritt, Henry G. Morse, John M. Cameron, Reynold T. Hall, and W. H. Pratt.

The Secretary called attention to the proposed publication of an index to engineering periodicals by F. E. Galloupe, of Boston. A committee of three was appointed to co-operate with similar committees from other societies in securing action in relation to the improvement of highway bridges. It was resolved to join in the invitation to the International Congress of Geologists to hold its next session in 1891 in Philadelphia. It was also resolved to appropriate \$100 from surplus funds of the Club for the benefit of the family of the late W. R. Kütter. The subject of the best form in which to continue to publish the Club reference book was referred to the Board of Directors.

Mr. E. F. Smith presented, for Mr. H. M. Sperry, an illustrated description of a Method of Displaying Titles on Blue Prints, by writing the title, number, etc., along *both* ends of the tracing, and, when printed, folding each end of print backward, in a fold about one half inch or so wide, and pasting it, back to back, so that when the print is on file, rolled, its title will always appear on the outside.

Mr. E. F. Smith presented a very completely illustrated paper upon Dam Building in Navigable Streams.

Professor J. W. Redway read a paper upon the Hydrography of the Mississippi River.

The Secretary presented, for Mr. Rudolph Hering, a Formula

for the Mean Velocity of Flow in Sewers, being a simplification, for field and general use, of Kütter's Formula.

The Club then adjourned until the first Saturday in October.

American Society of Civil Engineers.

THE annual convention began in Milwaukee, Wis., June 28, most of the members attending it having reached the city on the previous day. Special trains of cars were run from New York, Boston, and several other points. Mr. G. H. Benzenberg, of Milwaukee, was made Chairman, in accordance with the usual custom, by which the presiding officer of the Convention is always chosen from among the members resident in the place where it is held. The usual addresses of welcome were made and responded to. The routine business was followed by the reading of a paper on Friction, Waste, and Loss of Water in Mains, by Charles B. Brush, which was discussed by a number of members. At the afternoon session Mr. E. R. Tratman read a paper on English Railroad Track. In the evening the members attended a reception given by the Woman's Club of Milwaukee.

On the second day the morning session was taken up by the reading of a paper by J. T. Dodge on the Destruction of Rails by Excessive Weights and the discussion of the same.

The Committee on Uniform Standard Time reported that the system is making steady progress, meets universal favor on every railroad where it is in use, and that it is gradually being adopted for common public use in Manitoba.

The report was accepted and the Committee continued.

The Committee on Compression of Cement Mortars and Settlement of Masonry was continued and their report accepted and ordered printed.

The Committee to formulate recommendations with reference to titles and grades of engineers on public works, recommended:

1. That the title of chief engineer should be given to one having a supreme direction of work.

2. That the chief assistant engineer should be one who, when the magnitude of the work prevents the personal attention of the chief engineer, shall represent him in communicating with subordinate engineers.

3. That the division engineer should be one directing resident engineers on work whose magnitude prevents such direction from being given personally by the chief or chief assistant engineer.

4. That the resident engineers should be those having direct supervision of work in progress which receives their daily attention.

5. That the assistant engineers should be those employed directly under those above mentioned, in topographical, or instrumental work, or on plans of structures.

6. They deprecate the too frequent use of the title of consulting engineer, which should be used only by those acknowledged as authorities.

7. Specialist engineers may well assume such titles as hydraulic, sanitary, electrical, etc.

8. They recommend the title of chief engineer for the engineer in responsible charge of the public works of a city.

9. When the magnitude of the work does not require a chief assistant or division engineer, the resident, still giving personal daily supervision to all work under his charge, shall rank next to the chief engineer.

It had been a serious question with the Committee whether the titles of division and resident engineers should not be reversed. As some members of the Committee were absent, and the Chairman, Mr. Whittemore, desired their final indorsement and to perfect the wording of the report, it was provisionally accepted and referred back to the Committee.

A nominating Committee was then appointed. It was ordered that hereafter all committee reports must be delivered to the Secretary at least 60 days before the Convention.

Papers on the Kansas City Water Works, by G. W. Pearson, and on River Improvements on the Atlantic Coast, by Colonel W. P. Craighill, were read. In the afternoon there was a reception given by resident members of the Society.

On June 30 most of the members visited the Milwaukee Water Works and other points of interest. At the regular session a number of papers and discussions were read, including that on High Masonry Dams, by Mr. J. B. Francis.

In the afternoon the members visited a number of manufacturing establishments, including the Chicago, Milwaukee & St. Paul repair shops; the Milwaukee Cement Works; and the Reliance Works of E. P. Allis & Company.

At the session on Monday, July 2, Professor J. B. Johnson, of St. Louis, explained his arrangement for elaborate tests of wooden beams, for which a special machine is to be constructed. The reading of papers and written discussions was continued; the pressure of business was so great, however, that a large part of the papers had to be read by title only.

The Secretary then read a report on the Building Fund, stated the Society's condition, prospects, and the scope of its custodianship of records, valuable papers, etc., and appealed for private and corporation subscriptions for the $110,000 necessary to make up the $140,000 desired to build a plain fire-proof house for the use of the Society and the safe-keeping of its property.

The usual resolutions of thanks, etc., were passed, and the Convention adjourned.

The afternoon was spent in visiting points of interest about the city, and in the evening the annual banquet was held, over 200 persons being present.

On July 4 most of the members took a special train to the Springs at Oconomowoc and Waukesha, whence most of them returned to Milwaukee and started for home, a few, however, visiting Sault Ste. Marie.

American Society of Mechanical Engineers.

A RECENT circular from the Secretary, Mr. F. R. Hutton, contains the following preliminary announcement for the eighteenth convention of the Society, which will also be the ninth annual meeting.

"The Council have accepted the most cordial invitation of the Board of Trade of the city of Scranton, Pa., to hold its meeting in that city, beginning Monday evening, October 15, and a later circular will give the details of sessions, excursions, etc. The meeting comes somewhat earlier this year than usual, in order that the hill country of Pennsylvania may be enjoyed to the best advantage, and the meeting has been assigned, under the rules, for this date, with that object in view.

"The Society has so generally indorsed the plan of having all its papers in print and distributed in advance to those who expect to attend the meeting, that the attention of those who intend to be authors at this coming meeting is especially drawn to the necessity of having their papers, with illustrations, etc., complete, in the hands of the Publication Committee not later than August 20, 1888.

"The Secretary would solicit papers giving short accounts of engineering experiences, and also papers for the economic section of the Society's work on topics related to shop orders, methods of accounting, of superintendence, and management, and particularly of ascertaining cost of work.

"The Society's system of presenting and discussing papers enables it to handle exhaustively a large number of papers at a convention, and the privilege and duty of contributing in this way to the Society's work is urged on every one, even if he cannot expect to attend the meeting in person."

Association of Railway Telegraph Superintendents.

THE seventh annual meeting was held at the Murray Hill Hotel, New York City, on Wednesday, July 11, President Lang in the chair.

A number of new members were elected. After the reading and acceptance of the report of the Secretary and Treasurer, Mr. Bogart, from the Committee appointed last year to examine the various devices used for recording the signals transmitted over telegraph wires, made a verbal report. He had examined the self-starting registers manufactured by different establishments, and those of the Western Electric Company would be included in the exhibit of that company, which, with many others, would be ready for inspection Thursday morning. It was the intention to have the register operated by an electric motor in lieu of a spring or weight. An address was made by Commander A. D. Brown, of the United States Naval Observatory, on the Methods of Transmitting Correct Time. This was followed by an interesting discussion of the time question.

On Thursday the Committee reported upon the adoption of a substitute for the long dash now used as the character for the cipher. Mr. Selden reported in behalf of the Committee that a feeling existed among all people identified with telegraphy that they should not make any change in the Morse alphabet.

The following officers were elected for the ensuing year:

G. C. Kinsman, Decatur, Ill., President; C. A. Darlton, Washington, Vice-President; P. W. Drew, Chicago, Secretary and Treasurer.

The Committee appointed to fix the time and place of the next meeting reported in favor of holding it at Atlanta, Ga., on the third Wednesday in October, 1889.

The following resolutions were adopted:

"*Resolved*, That the Chair appoint a committee of five on electrical information, whose duty it shall be to disseminate matters brought to their attention by members of this Association.

"*Resolved*, That the Chair appoint a committee of three who shall select subjects and writers, said papers to be read at the annual meetings."

A paper on Electric Welding was presented by G. L. Lang, Mr. F. E. Kinsman also read a paper on an Electric Automatic Brake-Controlling Device.

The meeting then went into executive session and subsequently adjourned.

On Friday the members inspected the signals on the West Shore road at Weehawken, and also visited Manhattan Beach.

OBITUARY.

SAMUEL STILLWELL DOUGHTY, who died at Mount Kisco, N. Y., July 9, aged 77 years, was formerly an engineer and surveyor well known in New York City. He was for a number of years engaged in laying out the upper part of the city, and was also employed in the preliminary work on Central Park. He retired from business some years ago.

JAMES HARRIS, who died in St. John, N. B., July 6, aged 85 years, was born in Annapolis, N. S., but removed to St. John when a young man. In 1831 he started the establishment which has since developed into the extensive foundry, rolling-mill, and car-shops now operated by the firm of James Harris & Company. Mr. Harris was a man of strict integrity and great energy; in spite of his great age he continued to work until a short time before his death.

ROBERT HALE died in Minneapolis, Minn., June 28, from injuries resulting from a fall; he was 73 years old. Mr. Hale began his work in Vermont, and was, when still a young man, Superintendent of the Connecticut & Passumpsic Rivers road. Later he held similar positions on the Vermont & Massachusetts and the Boston & Albany railroads. In 1864 he was made General Superintendent of the Chicago & Alton, and held that office for seven years. He was then for three years General Superintendent of the Missouri Pacific, and on leaving that road settled in Minneapolis, where he was engaged in manufacturing. He always retained a lively interest in railroad matters. For four years past Mr. Hale had been Secretary of the Minneapolis Board of Trade.

HIRAM SIBLEY, who died in Rochester, N. Y., July 14, aged 81 years, was born in North Adams, Mass., and settled in Rochester when a young man. He was a man of active mind and keen foresight, and was one of the first to grasp the possibilities of the telegraph. In 1851 he bought the House patents and organized a company which soon owned many miles of wire. In 1856 he united his interests with those of the late Ezra Cornell, then head of a rival company, the result being the organization of the Western Union Telegraph Company. To Mr. Sibley's energy and persistence was mainly due the building of the first telegraph line through to the Pacific Coast, which was finished in 1861.

Mr. Sibley's next scheme was the construction of an overland telegraph line to Russia, and he devoted a great deal of time and energy to it. Surveys were made, and the line was built as far as Skeena River, in Alaska, when the successful laying of the second Atlantic cable put an end to the enterprise, and it was abandoned. In 1866 Mr. Sibley was forced by ill-health to give up the Presidency of the Western Union Company, which he had held since the formation of the company, and went to Europe for a complete rest. In 1869, his connection with the company terminated when he resigned the Vice-Presidency. He then sold out his telegraph interests and went into the seed business in Rochester and Chicago on an extensive scale.

Mr. Sibley has been a generous donor to the Rochester University and to the city, Sibley Hall having been built by him at a cost of over $100,000, and a library and other gifts are among his benefactions. The Sibley College of Mechanical Arts of Cornell University is the result of his old friendship for Ezra Cornell in the early days of telegraphy. He has been in feeble health for some time, owing to his advanced age.

PERSONALS.

WEBSTER SNYDER has resigned his position as General Manager and Chief Engineer of the Gulf, Colorado & Santa Fé Railroad.

L. B. PAXSON is now Acting Superintendent of Motive Power and Rolling Equipment of the Philadelphia & Reading Railroad, succeeding G. W. Cushing, resigned.

A. H. SMITH has been appointed Mechanical Superintendent of the Northern and Southwestern districts of the Grand Trunk Railway, with office in Toronto, Ont.

PETER CLARKE has been appointed Mechanical Superintendent of the Kingston-Toronto District of the Grand Trunk Railway.

J. W. AYER, of Kansas City, Mo., is Chief Engineer of the projected Kansas City & Sabine Pass Railroad.

JOHN HORNBY has been appointed General Superintendent of the Fort Worth & Rio Grande Railroad, with office at Fort Worth, Tex. He was formerly connected with the Marquette, Houghton & Ontonagon road.

SAMUEL REA, late Principal Assistant Engineer of Construction, has been appointed Assistant to the Second Vice-President of the Pennsylvania Railroad Company.

H. B. LA RUE, who for twelve years past has represented the Midvale Steel Company of Philadelphia, will sever his connection with that company on August 15. Mr. La Rue will take a well-earned rest, and will then take up a new line of work.

R. A. BACON has been appointed Superintendent of the Rome & Decatur Railroad. Major Bacon was until recently Secretary of the Georgia Railroad Commission.

H. G. RAWORTH, of Aiken, S. C., has claims to be considered the oldest living locomotive engineer. He entered the employ of the South Carolina Railroad Company as an apprentice in the shops in 1829, and in 1834 took charge of a locomotive on the road. He continued to run regularly until a short time ago. Mr. Raworth is now 77 years old, and is in excellent health.

H. J. SMALL has resigned his position as Assistant Superintendent of Motive Power of the Philadelphia & Reading Railroad, and will go to a California road.

J. L. GREATSINGER has been appointed Master Mechanic of the Duluth & Iron Range Railroad.

BRIGADIER-GENERAL JAMES C. DUANE, Chief of Engineers, U.S.A., has been placed on the retired list, having reached the age prescribed by law as the limit of active service.

COLONEL THOMAS LINCOLN CASEY has been appointed Chief of Engineers, U.S.A., in place of General Duane, retired. He is the son of General Silas Casey, U.S.A., and was born in 1833. In 1852 he was graduated first in his class at the United States Military Academy and assigned to the Corps of Engineers. From 1854 to 1859 he served as Assistant Professor of practical, civil, and military engineering at the Academy. During the War he was employed on engineer duty, at first in the West and afterward in the East. He was on special duty at the attack on Fort Fisher in 1864, and for services on that occasion was brevetted, and later received the brevets of colonel and lieutenant-colonel for faithful service during the war. For ten years, from 1867 to 1877, he was in charge of the division of fortifications in the Engineer Department at Washington, and was then placed in charge of public buildings. Under his supervision several important structures were reared. In 1868 he was sent to Europe to examine the torpedo system of foreign nations. Ten years later he undertook the completion of the Washington Monument, which he effected in 1884.

NOTES AND NEWS.

Electric Lighting of New York Harbor.—Arrangements for the illumination of Gedney's Channel, New York Harbor, have been perfected, and it is expected that contracts for the work will be made shortly. Six electric light buoys will be used, three on each side of the channel. They will be placed 1,100 ft. apart, and are expected to light the channel so that

vessels can enter the harbor at night as safely as in the daytime. The establishment of these lights will cost about $26,000, and they can by maintained at a cost of $3,000 a year.

An Unlimited Pass.—In 1836, when the Boston & Providence Railroad Company was chartered, Mr. John C. Dodge, of Attleboro, conveyed a portion of his land in consideration that he and his family should ride free over the railroad as long as the land was used for railroad purposes. A grand-daughter of Mr. Dodge claims that she is entitled to the privilege named in the deed, and that the word family meant "descendants" of the grantor. The railroad company demurred on the ground that the remedy of the plaintiff is at law and not in equity. Judge Allen overruled the demurrer, and expressed an opinion that under the deed the Boston & Providence Railroad Company would be required to carry free the descendants of Mr. Dodge for all time.

The New Naval Observatory.—The contract for the new buildings for the Naval Observatory has been awarded by the Secretary of the Navy to P. H. McLaughlin & Co., of Washington, the contract price being $307,811. This does not include the piers and domes, which will be built by experts under the supervision of the officers in charge of the Observatory. The new buildings will be on Georgetown Heights, near Washington, and will include the main building; the equatorial building, where the great telescope will be mounted; the clock-room, where the observatory clock will be set up and chronometers kept and regulated; two transit buildings; two observers' rooms; a boiler-house and engine-room. The buildings will be of Tuckahoe marble; they are to be begun at once and finished in 18 months.

The Trans-Caspian Railroad.—The Russians having opened their railroad from the Caspian to Samarcand are now busy discussing two proposals—one for extending her Rostoff-Vladikavkaz Railroad to Petrovsk, on the Caspian Sea, and another for pushing down to the same point the railroad system from Tzaritzin. In either case the European net-work would then be complete without break of any kind, to the Caucasus shore of the Caspian Sea; and the only water intervals between London and Samarcand would be the bit between Dover and Calais and the 16 hours' run by steamer between Petrovsk and Azoun Ada. With regard to completing the railroad system to the Caspian itself, the question now is upon the carpet, and we may expect to see the line commenced in a very short time.

A Swedish Ship Canal.—The Orebro Canal, in Sweden, an undertaking of considerable importance, will prove a great boon to the town of Orebro. Its object is to bring vessels from the Malar and Hjelmar lakes into the center of the town, whereas they have hitherto been only able to get within a mile or so of the town. Mr. W. Johansson is the Chief Engineer of the canal, and the work which was commenced in June, 1886, has been well carried out. The main canal has a breadth of 80 ft. to 90 ft. at a water line, and expands at the end into a basin of 150 ft. in breadth, with a high granite quay 1,211 ft. long. The granite quay on the northern branch of the canal has a length of 400 ft.; the canal is here 150 ft. broad. From this quay the vessels can pass into the water of the main canal through a swing bridge of iron, manufactured by the Arbogo Engineering Company.

Underground Railroad for Chicago.—Recently a company was incorporated to build an underground railroad for Chicago and the surrounding country. The company is limited by its articles of incorporation to a capital stock of $27,000,000. The incorporators are Chesley R. Crumpton, L. H. Clarke, George W. Wilson, George W. Waite, L. M. Nelson, Frank McMaster, James A. Slanker, and George H. Waite. The plan of the road contemplates digging a tunnel of sufficient capacity to admit of a double-track road, with shafts or stations every quarter of a mile, and the necessary elevators to handle passengers and freight business. The tunnel is to be lighted and drained, and to be built so far below the surface as to go beneath the sewers and water-tunnels. Among other things the company proposes to furnish connections for shifting freight between the various railroads reaching Chicago.

English Fast Trains.—The distance from London to Manchester by the Midland or by the London & Northwestern road is 184 miles, and by the Great Northern it is 203 miles. The fastest trains on all three of the roads make the trip in the same time (4¼ hours) making an average speed for the Great Northern train of 47.8 miles per hour, and on the other roads of 43.3 miles per hour. The three roads together run 23 trains each way which make the distance in less than five hours.

A recent change in time-table has shortened the running time made by the Great Northern Railroad in England between London and Edinburgh; the distance is 396 miles and the train goes through in 8¼ hours. Deducting the necessary allowance for stops, the average speed of this train is 49.6 miles per hour, which is about 2½ miles more than was previously made. The fastest time made by this train is over the section from York to Newcastle; the time allowed for the distance is 83½ miles in 97 minutes, an average speed of 51.6 miles per hour.

Russian Forests.—The Russian Government has at length taken measures against the destruction of the forests in the empire, which has gone on in all directions and has brought about climatic changes in the country, one of the most serious results being the shallowing of several harbors, ports, and large water-courses. The measures for carrying the foregoing into effect are intrusted to a commission with plans not only for the preservation of standing timber, but for the planting of saplings and the proper and regular thinning of forests. With regard to private woods, the measures issued by the Commission are to be applied with the consent and co-operation of the proprietors if possible. If the latter are opposed to such measures the property is purchased by the State at a certain valuation, and the necessary plans are carried out. The owners have a right within a certain period of repurchasing the property for the same price, but with the addition of the cost of introducing the measures and 6 per cent. per annum on the capital. In other cases the necessary steps can be taken without purchasing the property at the expense of the proprietor.

The Largest Electric Light in the World.—The English light-house authorities have recently placed what is claimed to be the most powerful electric light in the world in the new light-house at St. Catherine's, the southernmost point on the Isle of Wight. It is an incandescent light of 60,000 candle power, the carbon points used being no less than 60 millimeters, or nearly 2½ in. in diameter. The lamp is of the Serren-Berjot type, and, as the light-house is what is known as a rotating light, the whole apparatus is revolved by a small vertical engine, worked by compressed air, the speed being regulated automatically. The power is furnished by three engines, each of 12 nominal H.P., and capable of working up to 48 H.P., should occasion require. Usually only one of these engines is in use at a time although two or three of them can be put on; the intention is to keep one in reserve in case of accident. There are two dynamos, only one of which is used at a time. It is calculated that, if the whole power of the engines and dynamos are brought into use at the same time and concentrated, the light from the lantern will equal 6,000,000 candle power.

Non-Corrosive Propeller Blades.—As is well known an important question which marine engineers have been considering for some time is the discovery of an alloy which will resist the corroding and pitting to which cast-steel propeller blades are liable. The cost of bronze, phosphor-bronze, and other compositions is so high that the use of steel presents great advantages. At the recent meeting of the English Institution of Naval Architects a paper was read by John Willis, of Attercliffe, who claims to have discovered a method of preventing corrosion. His invention consists of a coating of copper united to a steel casting. The copper plate is bent into proper shape and is then placed in the mould, into which the iron or steel is poured, the result being that the copper is firmly united by fusion to the steel face. Other anti-corrosive metals can be used in place of copper. It is claimed that there is a perfect joint and that corrosion will be entirely prevented, while the cost will be very little above that of a plain cast-steel propeller. Mr. Willis's method is covered by a patent which he has obtained in England.

Limited Stock Companies in Mexico.—The law of April 7, published in the *Diario Oficial* of April 10, 1888, fixing the status and responsibility of stock companies in Mexico, is of special importance to those Americans who may now have or hereafter establish such companies in this country. The principal provisions are that the title must simply state the particular line of business for which they exist. For example, the Mexican Central Railway Company or the Mexican Fiber Company are *Sociedades Anónimas* within the meaning of the law. If the name of any shareholder appears in the title of the company he becomes personally responsible therefor. In an anonymous company the liability is strictly limited. Such a company may be organized in two ways; first, by public subscription; second, by two or more persons signing the articles before a notary. In the first sort the following are requisites:

1. The publication of the prospectus.
2. The subscription of the capital.
3. A general meeting to approve and ratify the constitution.
4. The notarial registration.

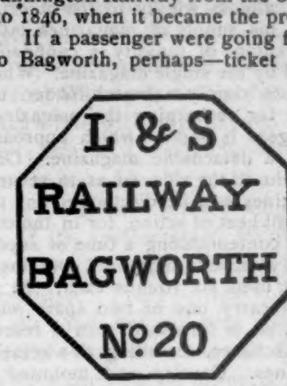
No company is legally constituted until the capital stock is fully subscribed and 10 per cent. paid in cash.—*Report of Consul-General Sutton to State Department.*

Age of Locomotives in Germany.—Herr Leonhardt, a German engineer, who has been investigating the subject, says that the number of locomotives in use on German railroads at the end of the railroad year 1885–86 was 12,450. The average age of the locomotives in use during the year of service 1884–85, was 12.60 years; and in 1885–86, 12.49 years. This is deduced from a table of the number of engines added and in active use for each year from 1843 to 1885. From this table it follows that 59 engines built prior to the year 1850 were running during the year 1885–86, and that the distinction of being the oldest running engine in Germany falls to one on the Holsteinische Marschbahn, which dates back to 1845. An examination of the table shows also that the average number of engines still extant is under 100 for each year prior to 1857; from 1858 onward the number rises steadily. Thus, in the year 1885–86, there were still 210 locomotives which began work in 1864. In the next few years the increase in numbers is still more rapid, and reaches in 1874 a maximum of 1,478 for the year 1884–85, and 1,464 for the year 1885–86. From 1878 until 1880 there is a steady decrease, which attains the minimum in the latter year. There are 131 engines of 1880 in 1884–85, and 132 engines of 1880 in 1885–86. The subsequent numbers again rise to over 500 for 1883; thus there were 517 engines which began work in 1883 in use during 1885–86.

Japanese Lacquer for Iron Ships.—The Japanese Admiralty has finally decided upon coating the bottoms of all their ships with a material closely akin to the lacquer to which we are so much accustomed as a speciality of Japanese furniture work. Although the preparation differs somewhat from that commonly known as Japanese lacquer, the base of it is the same—viz., gum-lac, as it is commonly termed. Experiments, which have been long continued by the Imperial Naval Department, have resulted in affording proof that the new coating material remains fully efficient for three years, and the report on the subject demonstrates that, although the first cost of the material is three times the amount of that hitherto employed, the number of dockings required will be reduced by its use to the proportion of one to six. A vessel of the Russian Pacific fleet has already been coated with the new preparation, which, the authorities say, completely withstands the fouling influences so common in tropical waters. It took the native inventor many years to overcome the tendency of the lac to harden and crack; but having successfully accomplished this, the finely-polished surface of the mixture resists in an almost perfect degree the liability of barnacles to adhere or weeds to grow, while, presumably, the same high polish must materially reduce the skin friction which is so important an element affecting the speed of iron ships. The dealers in gum-lac express the fear lest the demand likely to follow on this novel application of it may rapidly exhaust existing sources of supply.—*The London Engineer.*

Russian Railroads.—From a report just issued by General Possiet, Russian Minister of Ways of Communication, we gather that, at the beginning of the present year, there were 27,723 versts, or nearly 18,500 miles of railroad open for traffic in Russia, including the railroad system of Finland—a little over 1,000 miles—and that of the Trans-Caspian territory, 660 miles. The latter is described as a purely military line. In Finland the whole of the railroad system, except 20 miles, has been constructed by the Government. Of the general mileage of Russia, 5,488 versts belong to the State, and 20,785 to various companies, most of whom, however, are subsidized by the State, and more or less under Government control. The revenue last year on all the lines amounted to $122,000,000, of which $9,985,000 was derived from the State railroads. The increase was $13,810,000, or 11¼ per cent. over 1886. The best paying line was the Nikolaevsky, running from St. Petersburg to Moscow, which yielded 36,675 roubles per verst; the Moscow-Riazan followed with 30,029 roubles, the Riazan-Kozloff with 28,727 roubles, and the Warsaw-Vienna with 25,664 roubles. The Borovitchisk line yielded only 1,746 roubles per verst, and the strategical railroad through the Pinsk Marshes 1,376 roubles. The total number of passengers conveyed throughout the year was 34,757,923 civilians and 2,426,850 soldiers. The freight traffic amounted to 50,000,000 tons forwarded by slow trains and 160,000 tons by fast ones. In general, the year was a favorable one for the railroads; but, owing to the lowness of the exchange and the compulsory payment of many of the railroad loans abroad in cash, the financial results were, so far as the State was concerned, worse than usual.

Old Brass Tickets.—Mr. C. E. Stretton writes to the English *Mechanic* as follows: "The annexed illustration is a full-sized representation of the old brass railway tickets used on the Leicester & Swannington Railway from the opening of the line, July 17, 1832, to 1846, when it became the property of the Midland Company. If a passenger were going from any station—for instance, to Bagworth, perhaps—ticket No. 20 would be



issued to him, and this number and the amount of fare paid would be duly recorded in a book.

"The guard of the train carried a leather bag, somewhat in the form of a collecting-box, having a separate division for each station, into which the tickets were placed by the guard when collected, and returned to the station from whence they were issued, to be again used.

"These tickets appear to be such interesting relics of early railways, that I have lately presented one of them to the South Kensington Museum."

Railroads in the Philippine Islands.—Two projects to construct railroads on the island of Luzon, of the Philippine Archipelago, have been authorized by royal decree of the Spanish Government. The first is under a grant from the Government to an English firm in Liverpool represented in Manila by the firm of Smith, Bell & Company. It is proposed to build a line 18 miles long from Manila to Antipolo, where a religious festival is held once a year, which is attended by a number of pilgrims. A large revenue from the passenger traffic is expected during the festival.

The second project is more important. It is that of a corporation called "The Manila Railway Company, Limited." The company is formed for the purpose of constructing and working a railroad starting from a point in the district of Tondo, Manila, and terminating at Dagupan on the bay of Lingayen, its length being about 120 miles. The line already surveyed runs through a very fertile and populous country, and it is confidently expected that it will do an exceedingly large freight business.

Petroleum Deposits in Venezuela.—That part of the department of Colon, in Venezuela, situated between the rivers Santa Anna, Zulia, and the Sierra of the Colombian frontier, is very rich in asphalt and petroleum. Near the Rio de Ore, and at the foot of the Sierra, there is a very curious phenomenon consisting of a horizontal cave, which constantly ejects, in the form of large globules, a thick bitumen. These globules explode at the mouth of the cave with a noise sufficient to be heard at a considerable distance, and the bitumen, forming a slow current, falls finally into a large deposit of the same substance near the river bank. For a long distance from the site of this phenomenon the ground is covered or impregnated with petroleum.

Considering the great amount of inflammable gases which must be given out by the flows and deposits of petroleum described above, it may be easily believed that this has a direct bearing upon the phenomenon known since the Conquest as the "Faro" of Maracaibo. This consists of constant lightning without explosion, which may be observed toward the southward from the bar.

The State of Zulia, in which are situated all the deposits of coal, asphalt, and petroleum, is as yet free from any monopolistic concession; but this cannot last forever, and it remains to be seen whether American enterprise and capital will eventually take in hand the development of a most profitable industry.

The New English Magazine Rifle.—The following particulars connected with the proposed new magazine arm will

doubtless be interesting to many. The bore is 0.303 in. diameter, giving about 33 per cent. more rounds than the Martini-Henry for the same weight of ammunition. It has a detachable magazine. Experiments with the troops at Shorncliffe with the Martini-Henry, with a rifle with a fixed magazine, and also one with a detachable magazine, have shown that the last has a great advantage, arising from the circumstance that when a magazine is empty another filled magazine can be put in its place in the same time that it takes to get a cartridge out of the pouch and load with it. Thus the soldier is able to keep his attention directed almost wholly to the object at which he is firing, so long as his supply of magazines lasts. In a fixed magazine the advantage of rapidity is confined to the number of rounds supplied by the single magazine. When they are discharged, the rifle is simply a breech-loader, until a suitable opportunity arises for recharging the magazine, unless some special charging gear is applied which approaches in degree the conditions of a detachable magazine. One magazine is attached by a chain to the rifle, so as to secure its retention. Subsequent magazines may be discharged and thrown away, if necessary, in the full heat of action, for in the continued use of magazines we are contemplating a time of supreme stress and importance. The attached magazine contains eight rounds, those subsequently used six rounds each. At present the infantry soldier will carry one or two spare magazines; thus, with the first one, he is furnished with a reserve of 14 or 20 rounds for rapid discharge, according to whether he has one or two spare magazines. Cavalry and mounted infantry could carry bandoliers with eight or ten detachable magazines. Sergeant Beckwith, of the Tenth Hussars, carried eight magazines in his bandolier during the experiments. Mounted infantry thus become specially formidable, for it may be noticed that, both as to carriage power and the object of despatching them to produce a rapid, telling blow, magazines in bandoliers are admirably adapted to their case. Three hundred and fifty rifles are ready for the troops. The Rubin cartridge is to be used experimentally, but English ammunition is progressing, and will, it is hoped, be ready when the experiments are over.—*The London Engineer.*

Fuel-Testing Stations.—A writer in *Nature*, Mr. Bryan Donkin, Jr., proposes the establishment in London of a station of this kind, of which there are now a number in operation on the Continent. He says:

"So far as I know, there does not exist anything of the kind in England where, as on the Continent, coals can be tested for their evaporative power, the gases of combustion analyzed, and all the results carefully reported on by experts. It should, I consider, be placed on a perfectly independent footing, and managed by experts, under a small committee appointed by those who assist with money or otherwise. It might follow generally the lines of existing coal-testing stations, but with all modern improvements.

"In this country (England) it is remarkable that neither the sellers of coal take the trouble to find out how much heat they are offering, nor the purchasers how much they are getting for their money, and this notwithstanding the hundreds of millions of tons of coal changing hands yearly. Colliery-owners and coal-merchants, as well as the large consumers, know very little about coal calorimeters, although the former sell so much heat, and the latter try to utilize it to the best advantage. How few of the latter weigh their coal regularly, or keep any weekly record of the quantities of ashes and clinkers, to find out how much dirt and incombustible matter they are paying for! How few know what it costs them in fuel to evaporate one thousand gallons of water into steam, which is one of the best standards of comparison in a given district!

"The station would require to be advertised and made known in various ways. Colliery-owners would no doubt find it to their advantage to have their different kinds of coal tested and reported upon, so as to offer them to their customers with their ascertained heating value or evaporative power. Large consumers of coal (railway companies, water-works, and others) should know the heating value of the coal they are paying for, and the percentage of incombustibles."

What is said of England is equally true of this country. With the great variety of coals in this country it would seem as though it would be profitable to have some reliable authority to determine their values.

The correspondent mentions the following experimental fuel-testing stations on the Continent:

"The Imperial Naval Administration Coal-Testing Station at Wilhelmshaven, Germany, was established in 1877.

"Dr. Bunte's coal-testing station, erected at Munich about 1878, particulars of which have been published in the *Proceedings* of the Institution of Civil Engineers, vol. lxxiii. Here some hundreds of trials have been reported on and published; much valuable work has been done, and many fuels tested, including coals of the Ruhr Valley, Saar Basin, Saxon and Bohemian coal-fields, and those of Silesia and Upper Bavaria. The boiler of the station has about 450 square feet of heating surface. The gases and coals are analyzed, and all particulars carefully noted. It is one of the most complete stations I have seen.

"In Belgium, near Brussels, there is a Government station for testing fuels, under the administration of the Belgian State railways; locomotive boilers are used. The establishment has been at work for the last two years, but no results are published, as they are considered the property of the Government. Private firms can, however, have their coals tested and reported upon.

"The Imperial Marine Station, Dantzig.

"Boiler Insurance Company at Magdeburg."

Foreign Naval Notes.—The ironclad *Emperor Nicholas* ready to be launched on the Neva for the Russian Baltic Fleet, is of 8,500 tons, 330 ft. long, 63 ft. broad, and 21 ft. deep, furnished with engines of 8,000 indicated H.P., steaming at 16 knots. The armor plating of the vessel is 10 in. thick, and she will carry eight 8-in. and ten 6-in. guns. The *Pamiatz Azova*, a cruiser of 6,000 tons displacement, 354 ft. long, 49 ft. broad, and 23 ft. deep, intended for the Pacific service is also just ready. Her engines are of 8,500 indicated H.P., steaming at 17 knots. She is protected at places with from 8 in. to 10 in. of armor plating, and her armament comprises two 8-in. guns and four 6-in. Both vessels are being built at private yards.

Four new armored-deck ships of the *Dogali* type are to be laid down at once for the Italian Navy. The *Dogali* is a torpedo ram cruiser, with a deck armor 150 millimeters thick, and of 2,050 tons displacement, and is fitted with engines of 7,500 H.P., which have propelled the vessel at a speed of 20 knots. She is armed with six 15-centimeter guns and 15 mitrailleuses. Four new torpedo cruisers of the *Tripoli* class are also to be built. They will have deck armor 25 millimeters thick, a displacement of 741 tons, and three engines of 4,200 H.P., working three screws, which will give them a maximum speed of 23 knots. These screws are three-bladed, and two of them are placed at the same height at the base angles, the third screw at the acute angle of a triangle directed with its point downward. Italian naval officers consider this arrangement very efficient, not only for the attainment of a high speed but also for maneuvering vessels. The four vessels will be armed with eight quick-firing guns and three mitrailleuses. It has been further decided to build five torpedo avisos of the *Folgore* type, intended for the pursuit of torpedo boats. They will have, like her, a displacement of 317 tons, engines of 2,800 H.P., a speed of 20 knots and be armed with two quick-firing guns and four mitrailleuses. A large number of sea-going torpedo boats are also to be constructed immediately. The Government dockyard at Castellamare is at present engaged on the construction of a vessel each of the *Dogali*, *Tripoli*, and *Folgore* type, respectively.

An article in *Les Annales Industrielles* gives the following list of cruisers in the French Navy:

Broadside cruisers, seven; three are of iron and run 17 knots an hour. The *Duquesne* and the *Tourville* are 12 years old; the *Sfax* alone is a modern ship. The rest are of wood, and, therefore, they do not fulfill in any respect the conditions of the war of the future. The *Iphigénie* and the *Naïade* are old-fashioned.

First-class cruisers, nine; all are of wood except the *Duguay-Trouin*, and run from 14 to 15 knots.

Second-class cruisers, ten, all of wood, with widely-differing capabilities; not one of them could run 15 knots on service. We must not omit, however, the *Milan*, of steel, which runs 18 knots, but which is only a dispatch vessel with limited action.

Third-class cruisers, nine, all of wood, of no great value. They are being struck off the list annually.

Torpedo catchers, three. The *Condor*, the *Epervier*, and the *Faucon* are afloat, running 18 knots. Sphere of action very limited. It is useless to class the wooden-dispatch boats.

In addition to these there are now in the dockyards, or just launched, the following ships:

Broadside cruisers, three. The *Dupuy-de-Lôme*, of 6,300 tons; the *Cecille*, 5,766; the *Tage*, 7,045; the two last are launched, and ought to run about 20 knots. The *Dupuy-de-Lôme* will be completely armored, but it is hardly commenced, and judging by the pace at which constructions progress in France, it may be predicted that it will not be armed before the end of 1891.

First-class cruisers, three, of 4,160 tons and 19 knots speed; second-class cruisers, two, of 3,025 tons and 20 knots speed; third-class cruisers, six, of 1,850 tons and 19 knots speed. There are also one torpedo catcher and three dispatch boats.